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Institutional Responses to Contamination of Ground Water Used for Public Water Supplies Implications for EPA Research and Development Programs

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INSTITUTIONAL RESPONSES TO CONTAMINATION OF GROUND WATER USED FOR PUBLIC WATER SUPPLIES: IMPLICATIONS FOR EPA R&D PROGRAMS

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16. ABSTRACT

This report is organized into sections addressing the methodology employed, characteristics of the cases analyzed, research and development needs, and conclusions on trends in organic contamination of ground water. The methodology section describes the procedure used in identify water systems with contaminated ground water and to select the cases studied in depth. The analysis section describes various technical and organizational aspects of the case studies, as well as problems commonly encountered. The section on ground-water research discusses the areas of assistance most frequently requested by municipalities and states with ground-water problems and outlines these areas in a format consistent the Envioronmental Protection Agency's Drinking Water and Ground Water Research Plans.

Serveral important components of this report are included as Appendices. These include the results of the initial survey of water systems, the complete case studies (the subject of most of the effort expended in this assessment) and a list of contacts at every agency involved in each case. The last two items, especially, will be valuable for follow-up studies on specific technical topics.

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EXECUTIVE SUMMARY

The objectives of this ground-water assessment for the EPA Office of Research and Development are threefold. The first objective is to improve EPA's understanding of problems faced by the states and municipalities in ensuring that ground-water is safe for drinking. The second objective is to provide guidance to EPA in setting research and development priorities in ground-water and drinking water areas. The final objective is to present the data on the original and final sets of ground-water contamination cases examined, with source lists for contacts at each organization dealing with the problem. These objectives reflect revisions made in the work plan which originally called for a mini-assessment of trends in ground-water pollution.

The scope of this assessment was defined to include public water systems with confirmed drinking water contamination from synthetic organic chemicals in ground-water. A preliminary list of municipalities with ground-water contamination problems was developed to select a group of cases for in-depth analysis. These cases, chosen with the assistance of regional EPA and state officials, were studied through site visits and extensive telephone interviews.

CONTAMINATION TRENDS

Several distinct patterns of ground-water problems became apparent. Eighty percent of the cases involved trichloroethylene, detected at levels as high as 5,700 ppb in public wells. Tetrachloroethylene, trichloroethane, and other volatile halogenated organic compounds were detected less frequently, and at lower levels. The major sources of these organic solvents were military contractors or airports, followed closely by plating industries, electronics industries, and chemical waste handlers/landfills. Leaking underground tanks or improper disposal of solvents were identified as the most common point sources of pollution. It is important to note that a large number of other cases of ground-water contamination are likely to exist but have not been discovered or made public due to the same fears and uncertainties exhibited by public officials in the cases studied.

PATTERNS OF INSTITUTIONAL RESPONSE

Several patterns of institutional response also became apparent. In a typical case, organic-contaminated drinking water was discovered accidentally or by state officials testing suspected or random sites. The local water utility usually closed the contaminated wells immediately and invoked conservation measures or purchased water to replace lost capacity. At this point the state and technical consultants joined in investigations to determine the source of contamination and to restore long-term water supplies. In the majority of cases, new or recompleted wells were selected as a long-term water source, rather than water treatment or aquifer rehabilitation.

In a typical case, the local water authorities would be working with the county health or environmental department, the state health department and environmental agency, and regional EPA officials. The capabilities of state agencies, which often took the lead in resolving ground-water contamination cases, varied widely. The State of New York, for example, has studied organics in ground water extensively, while Washington barely has enough staff or funding to conduct any investigations at all. Several states, such as Arizona, have set up their own versions of Superfund (CERCLA) to attempt to respond to hazardous waste problems. The Department of Defense has also become involved in a significant number of cases through programs such as the Air Force's Installation Restoration Program.

RESEARCH AND DEVELOPMENT NEEDS

The major technical deficiency encountered was a paucity of information on the health effects of organics in drinking water and a lack of consistent health guidelines. Evaluating the hazards of keeping contaminated wells in service, informing the public, and designing treatment techniques were all made difficult by weaknesses in health data and inconsistencies in recommended allowable levels of contamination.

Testing and monitoring techniques appeared adequate in most cases. Research on more comprehensive and less expensive methods of analysis would, however, aid in the detection and resolution of organics contamination cases, as would standardized protocols for monitoring. Tracing the sources of organics in ground water proved to be a more serious problem. Several investigations were limited by costly drilling techniques, the complicated data requirements for ground-water modeling, or an overall lack of institutional coordination. Many regions also face a shortage of qualified hydro/geological personnel to carry out extensive subsurface studies.

The state-of-the-art of treatment techniques to remove organics from drinking water was generally not a limiting factor, and either EPA or engineering consultants had enough knowledge to install a pilot plant and design an effective treatment plant. Aeration techniques were usually selected although little is known about the levels of air contamination due to aeration. The major constraints in designing treatment methods are the uncertainties in specifications for allowable effluent levels of organics, not the efficacy of removal technologies.

In conclusion, most municipalities examined in this study handled the problem of organic chemicals in their ground water fairly well, but more work is needed to improve several areas of response. The most critical R&D need for states and municipalities is in health effects research, followed by establishment of consistent guidelines or standards for organics in drinking water. The dissemination of technical information on detection, analysis, and engineering control techniques is also necessary to help local and state officials to make informed decisions on resolving problems with organic contaminants in ground water.

I. INTRODUCTION

This study was commissioned by EPA to investigate trends in cases of ground-water contamination and to evaluate research and development needs of municipalities with contaminated ground-water supplies. This section presents background information on the growing problem of organic contaminants in ground-water sources used for drinking water supplies, elaborates on the purpose of this investigation and outlines the content of the report that follows.

BACKGROUND INFORMATION ON GROUND WATER CONTAMINATION

Ground water is a vast but vulnerable natural resource. About 25 percent of all fresh water used in this country comes from ground-water sources, and somewhat over 50 percent of the U.S. population relies on ground water, often untreated, as a primary source of drinking water.[1] Ground-water use is proportionately higher for small water utilities and in rural areas, where over 90 percent of the population is dependent upon public or, more often, private wells for drinking water.[2] Considering the fact that over 20 trillion gallons of ground water are withdrawn annually, one might suspect that the nation is facing a problem with the quantity of the ground-water resource. Except for arid regions in the West, however, natural recharge is usually ten times as large as withdrawal, and overall ground-water quantity is not a problem.

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[1] U.S. Environmental Protection Agency, Office of Drinking Water, Planning Workkshop to Develop Recommendations for a Ground Water Protection Strategy: Appendices, Washington, D.C. U.S. Government Printing Office, 1980 p. IV-1.

[2] Murray, C.E., and Reeves, E.B., Estimated Use of Water in the United States in 1975, Geological Survey, Circular 765, Arlington, VA, USGS, 1977, p. 20.

The current problem associated with ground-water supplies is with quality, not quantity. Although ground water had always been considered a secure, pristine resource, recent discoveries indicate that contamination from various sources is a problem in many locations. One potentially serious trend becoming evident is that many instances of ground-water contamination are associated with organic chemicals. The earlier national organics monitoring programs focused attention on trihalomethanes in surface-water systems, and as recently as four or five years ago, ground water was still thought, by most, to be relatively secure from organics contamination.

Three major national studies by EPA from 1975 through 1979 showed that a number of volatile chlorinated hydrocarbons (besides trihalomethanes) were frequently found in ground water.[3],[4],[5] More recent studies, focusing more on ground water, such as the Ground Water Supply Survey, the Community Water Supply Survey, and the Rural Water Survey confirmed earlier reports that several organic chemicals associated with solvents, especially trichloroethylene and tetrachloroethylene, were present in a significant number of water systems using ground water.[6] The occurence of organic chemicals in drinking water from ground-water sources has been recognized as a potentially serious health hazard.

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[3] Symons, J.M. et al., "National Organic Reconnaissance Survey for Halogenated Organics," Journal of the American Water Works Association, 67:234 (1975).

[4] U.S. Environmental Protection Agency, "Organic Chemicals in Drinking Water," Washington, D.C. 1978.

[5] Information on the National Organics Screening Program (NOSP) provided by the Criteria and Standards Division, Office of Drinking Water, U.S. Environmental Protection Agency, Washington, D.C.

EPA has reacted to requests for assistance by states and to its congressional mandate to carry out the Safe Drinking Water Act and other statutes in a number of ways. One major program is regulatory in nature, to set standards and guidelines to protect the public health and to restrict the use and disposal of chemicals and hazardous wastes. A recent survey showed that EPA drinking water research and development assistance was the highest priority request from the States.[7] In support of the regulatory role and to provide technical assistance to municipalities, states, and Regions with concerns about organics in ground water, EPA has developed a ground-water research program.

The EPA drinking water research plan recognizes that the largest areas of ignorance in the drinking water field are related to the measurement, assessment, chronic health effects, and treatment of trace organics in ground water. This study was initiated to investigate trends in cases of ground-water contamination and to comment on the needs of States and municipalities in studying and resolving local cases of drinking water problems caused by contaminated ground water.

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[6] Coniglio, W.A., Miller, K., and MacKeever, D. "The Occurrence of Volatile Organics in Drinking Water," U.S. Environmental Protection Agency, Office of Drinking Water, briefing paper, March 6, 1980, p. 10.

[7] U.S. Environmental Protection Agency, Office of Research and Development "Decision Unit Analysis - Drinking Water," prepared for the Office of Management and Budget, 1982, p. 1.

PURPOSE OF STUDY

Orginally, this study was intended to be a mini-assessment of trends in ground-water pollution. Early discussions between the Office of Research and Development and ICF Incorporated centered around a proposed work plan to characterize the current extent of ground-water contamination, project trends in ground-water contamination, assess the potential health hazards associated with these trends, and to identify policy implications, information gaps, and research needs. After ICF presented its detailed work plan for the mini-assessment, ORD decided that the available data were inadequate to fully support the type of inquiry initially sought and that a change in study emphasis was mandatory. The background research and investigations preceeding this decision are not presented in this report.

The scope of the effort was changed to provide a narrower but more in-depth study. The main tasks of the revised work plan were to:

- identify cases of drinking water contamination associated with ground-water contamination;
- contact the local and state organizations involved to determine the facts of each case, institutional responses, and any difficulties encountered;
- organize the findings to permit others to derive insights on preferred methods in technical areas such as detection, analysis, monitoring, or treatment; and
- use the data to derive suggestions for EPA research needs.

The procedures used to perform these tasks are described in the section entitled Methodology.

OUTLINE OF REPORT

The remainder of this report is organized into sections addressing the methodology employed, characteristics of the cases analyzed, research and development needs, and conclusions on trends in organic contamination of ground water. The methodology section describes the procedure used to identify water systems with contaminated ground water and to select the cases studied in depth. The analysis section describes various technical and organizational aspects of the case studies, as well as problems commonly encountered. The section on ground-water R&D discusses the areas of assistance most frequently requested by municipalities and states with ground-water problems and outlines these areas in a format consistent with EPA's Drinking Water and Ground Water Research Plans.

Several important components of this report are included as Appendices. These include the results of the initial survey of water systems, the complete case studies (the subject of most of the effort expended in this assessment) and a list of contacts at every agency involved in each case. The last two items, especially, will be valuable for follow-up studies on specific technical topics.

II. METHODOLOGY

Since the data available on ground-water contamination are inadequate to support a statistically-based inquiry, the case study method was chosen to gain an in-depth understanding of the problems involved in responding to ground-water contamination. Briefly, the general approach in the project was to:

- Compile data on cases of drinking water problems associated with ground-water contamination;
- Select a cross-section of cases for in-depth analysis, involving site visits and phone interviews;
- Contact the key individuals in the selected group of cases to obtain detailed information on how the water utility discovered and dealt with the problem;
- Identify common patterns of problems and responses; and
- Make suggestions on research and program needs to EPA, based on the findings of the cases studied in depth.

A more detailed explanation of the methodology is presented below.

INITIAL INVESTIGATION

In compiling data on cases of drinking water contamination, an effort was made to investigate those cases considered significant by state and local authorities. State public health agencies were contacted to identify instances of drinking water problems caused by actual or potential ground-water contamination. The data compiled on each case included location, contaminants identified, and a brief description, if possible, of the extent of the problem and any action taken. Over one hundred cases in the ten regions were identified in this step. Several criteria were established to narrow the scope of the investigation. Those cases that clearly did not include public systems, those that involved only inorganic contaminants (including heavy metals), or those which were known to be actively involved in lawsuits were screened out. Seventy-seven cases passed this screen and were considered for the final analysis. A review of the cases indicates the following characteristics:

- Geography: The 77 sites identified were concentrated in areas of high population density, indicative of more frequent contamination as well as more intensive water testing:

Region	No. of Sites Identified
1	4
2	27
3	7
4	8
5	12
6	1
7	3
8	--
9	9
10	6
Total	77

- Contaminant: Some cases involved more than one contaminant. The preliminary data collection effort yielded the following contamination pattern:

Contaminant	No. of Cases Identified
Trichloroethylene (TCE)	39
Unspecified "Organic"	17
Tetrachloroethylene	9
Unspecified "Solvents"	6
PCB	6
Trichloroethane (TCA)	5
Toluene	4
Dichloroethylene (DCE)	3
Acetone	2
Dibromochloropropane (DBCP)	2
Phenols	2
Benzene	2

If the cases identified as unspecified "organics" or "solvents" are attributed to TCE (the preliminary investigation indicates this is likely), then 81 percent of the seventy-seven cases involve TCE. Nineteen contaminants identified only once are not listed above. One possible fault with the table above is that some officials might have confused TCE with TCA.

- Source of contamination: Where the source was identified, almost half of the cases were associated with landfills or waste dumps. Another twenty to thirty percent were linked to industrial sites. A smaller proportion of cases were linked to buried pipe or tanks and septic systems.
- Magnitude of problem: The populations affected ranged from less than 1,000 persons to over 400,000. Most water systems affected appeared to be in the range of 2,500 to 50,000 customers.
- Action taken: In cases where responses to contaminated drinking water were reported, over half of the systems closed down one or more wells. Roughly fifteen to twenty percent either changed supplies or purchased water, and about ten percent of those systems that reported taking action implemented granular activated carbon (GAC) treatment, aeration, or other advanced treatment methods.

CASE SELECTION

Site characteristics such as location, contaminants, source of contaminants, magnitude of the problem, and action taken were considered to assemble an intermediate group of cases representative of the whole. Regional EPA and state drinking water officials were then contacted for assistance in selecting the final group of cases for site visits and interviews. In some instances, the cases they suggested for analysis involved a more serious problem or had received more publicity than a "typical" case, so an effort was made to balance the relatively controversial cases with more ordinary ones. The regional and state officials identified those cases where knowledgeable local officials were actually available for detailed interviews. The cases selected for study differ from a truly representative sample in that the information about how each community detected and responded to its drinking water problem was readily available.

Since the final set of cases was selected on the basis of several general criteria, rather than chosen randomly, statistical measures of the study results are inappropriate. The field experience and in-depth examination of a small number of cases, however, provide an understanding of typical problems and responses from which general inferences can be drawn.

Budget constraints dictated that only a limited number of cases could be investigated in depth. A two-tiered approach was proposed to study as many cases as possible while allowing in-depth analysis. Two sets of cases were selected: a group of seven cases designated for site visits and a group of eight cases studied through extensive telephone interviews. The more complicated cases, listed in Exhibit II-1, were selected for site visits because numerous officials had to be contacted to trace the decision-making process. The second group of cases, listed in Exhibit II-2, were more clear-cut so that telephone interviews were usually adequate. The following table displays the distribution of those cases investigated in-depth by Region and state.

DISTRIBUTION OF CASE STUDIES

EPA Region	State	Site Visits	Telephone Interviews	Total Cases
I	Massachusetts	-	1	1
II	New Jersey	1	1	2
	New York	1	2	3
III	Pennsylvania	-	1	1
IV	Florida	-	1	1
V	Indiana	1	-	1
	Michigan	1	1	2
	Minnesota	-	1	1
IX	Arizona	1	-	1
	California	1	-	1
X	Washington	1	-	1
Totals 7	11	7	8	15

EXHIBIT II-1

CASES STUDIED BY SITE VISITS

Case	Contaminants	Extent of Problem	Additional Information
Region II			
Rockaway Township, NJ	TCE, di-isopropyl ether methyl tertiary butyl ether	1 of 3 wells heavily contaminated, problem may be spreading.	Contaminated well pumped as an interceptor, GAC filtration used, had to install aeration for new problems.
Glen Cove, NY	Tetrachloroethylene 1,1,2 Trichloroethylene	4 of 7 wells closed due to contamination.	Town brought water and added new wells to meet demand.
Region V			
Elkhart, IN	TCE, Other VOCs	City's largest well field is affected.	Interceptor well used to prevent spread of plume.
Battle Creek, MI	Seven different VOCs	Half of municipal wells contaminated.	Accidentally discovered--wells closed, problem not yet resolved.
Region IX			
Tucson, AZ	TCE	Five high-production municipal wells closed, sole source aquifer affected--major problem.	The industrial source and various agencies are involved in evaluating and treating the problem.
San Jose, CA	Trichloroethane	One well of investor-owned utility is highly contaminated, complex aquifers affected.	Well is pumped through filtration to storm sewer, industrial source cooperating with monitoring and clean-up assistance.
Region X			
Lakewood, WA	TCE, Tetrachloroethylene 1,2-Dichloroethylene	Two wells with high concentrations closed, now system cannot meet summer demand.	Many organizations involved in pinpointing source.

EXHIBIT II-2

CASES STUDIED BY PHONE INTERVIEWS

Case	Contaminants	Extent of Problem	Additional Information
Region I			
Bedford, MA	TCE, Dioxane	4 wells supplying 80% of town's water affected.	Wells closed, extensive search for new water supply underway.
Region II			
South Brunswick, NJ	TCE, trichloroethane Dichloroethylene	One-third of water supply affected.	Contaminated well pumped to waste, new well being drilled.
Garden City Park, NY	Tetrachloroethylene	3 of 9 wells contaminated, cannot meet peak demands.	New well drilled, useage restrictions implemented.
Vestal, NY	TCE, Other Organics	One of Water District #4's three wells had to be closed.	Granular activated carbon used temporarily until new well drilled.
Region III			
North Pennsylvania Water Authority, Lansdale, PA	TCE, Tetrachloroethylene	Closed 7 of 50 wells for excessive levels of TCE, one well closed because of tetrachloroethylene.	Increased pumpage and brought water. GAC system installed.
Region IV			
Vero Beach, FL	TCE	Leakage of TCE from buried tank heavily contaminated one well and forced its closure.	Source was identified, interceptor well drilled to keep plume from well field.
Region V			
Petoskey, MI	TCE, CIS-1,2 Dichloroethylene	Sole source aquifer contaminated.	New water supply being investigated.
New Brighton, MN	Various VOCs	5 of 6 municipal wells and many private wells are contaminated.	3 worst wells closed, cannot meet demand, looking for federal money for new water source.

STUDY PROCEDURE

The first step in investigating the final set of cases was to identify the lead agency responsible for coordinating actions taken in response to each case of organics in ground water. Interviews with officials at the lead agency were followed by contacts with other organizations involved in particular aspects of the problem. Often, the interviews would trace two different paths of response to the contamination problem: the local and health agencies concerned with supplying safe drinking water, and the state environmental and EPA offices responsible for finding and halting the source of contamination. As many as eight agencies were contacted in the course of a single case study.

Both the site visits and the extensive telephone interviews were structured around a general set of questions. The interview format was tailored to each case and each agency involved to maximize the amount of detailed information gathered and to avoid redundant questioning. The use of interviewers knowledgeable about municipalities' problems with organics in drinking water allowed some flexibility in studying each case and eliminated the need for a formal, more limited interview methodology.

A sample set of questions, included as Appendix B, shows the type of information typically gathered. The sample questions are divided into categories including general information about the contamination problem, how the organics in drinking water were detected, how the scope of the problem was evaluated, and what actions were taken in response. This list of questions was developed to guide the interviewers. It was not used in a survey context.

III. ANALYSIS OF CASES

A case study was written on each of the ground-water contamination incidents investigated through site visits and telephone interviews. The full description of each case is included in Appendix C. The description of the cases studied through site visits are of course more detailed than those studied through telephone interviews, but both types are organized in the following format.

Summary
Discovery of the Contamination Problem
Actions to Protect Water Quality
Current Status
Institutional Involvement
Health Guidelines
Conclusions

The case studies provide useful accounts of the chronology of events, the factors contributing to decision-making, and the problems encountered in response to each incident of organics in ground water used for public drinking water supplies. The overall progression of events and organizational responsibilities in the cases should be helpful in explaining how a typical contamination problem is handled. A detailed source list of over eighty persons contacted for information on the cases is included as Appendix D.

To allow examination of trends and problems in particular aspects of ground-water contamination cases, the important factors in each case were also broken out horizontally. Topic areas addressed include the contaminants involved, usual sources of ground-water contamination, the means by which contamination was detected, whether aquifer contamination could have been prevented, actions taken in response to contamination, and a comparison of various state health guidelines. Section IV contains an in-depth discussion of the technical problems encountered in ground-water contamination cases.

Organic Contaminants Detected

The scope of this study was limited to cases of drinking water contamination caused by organic chemicals in ground water. In both the preliminary data collection effort and the final set of case studies, trichloroethylene was, by far, the most prevalent synthetic organic compound present in groundwater supplies. The preliminary survey indicated that fifty to eighty percent of the cases screened involved trichloroethylene, often in conjunction with other organics. In the 15 in-depth studies, eighty percent of the sample cases involved trichloroethylene; other organics were present in greater than trace amounts as indicated below.

	Occurrences	Highest Level Detected in Public Well
Trichloroethylene	12	5,700 ppb
Tetrachloroethylene	7	375 ppb
1,1,1 trichloroethane	5	1,500 ppb
1,2 dichloroethane	3	12 ppb
1,1 dichloroethylene		
cis-1,2 dichloroethylene	5	79 ppb
trans-1,2 dichloroethylene		

Single incidents of contamination by vinyl chloride, methyl tertiary butyl ether, diisopropyl ether, phallates and dioxane were also noted. Several associated or degradation compounds often present at lower levels than the "primary" organic contaminants were not always reported, on the assumption that they would also be controlled by whatever means was chosen to control the "primary" contaminants.

As shown, trichloroethylene was, by far, the most ubiquitous contaminant reported. The insights gained through the case studies indicate that the majority of contaminants reported generally as "organics" or "solvents" probably are trichloroethylene, with trichloroethane or tetrachloroethylene being the other most prevalent compounds.

Trichloroethylene (TCE) seems to have become the "reference standard" for organic compounds in ground-water contamination, although other studies have mentioned that 1,1,1 trichloroethane is the compound most often detected in certain states. Several offices reported that the presence of TCE is generally used as an indicator for more hazardous compounds usually found in much lower concentrations, such as 1,2 dichloroethane.

It also should be noted that levels of organic contamination in industrial or private wells were usually higher than in public wells. This occurs because the industrial wells are closer to the contamination site and because the more numerous private wells are usually completed in shallower, more vulnerable aquifers. Most states have regulations mandating an undeveloped zone around public wells, but private wells have traditionally been less protected. Additionally, private wells are more common in the older parts of municipal areas, where medium to heavy industry has often been operating (and using organic solvents) for many years, than in the newer suburbs.

In the cases studied, it would not be unreasonable to state that at least five to ten private wells were known to be contaminated for every municipal well contaminated by organics. Although fewer persons in municipal areas rely on private supplies than on public drinking water, the degree of contamination is usually significantly higher. For this reason and since the option of connecting to public water is usually available in municipal areas, steps to protect private well owners should be considered when organics contamination is detected at public wells. The County Health Departments have usually supervised testing of private wells, while State Health Departments oversee public water supplies.

Sources of Contamination

Several definite trends were observed in the sources of organics contributing to ground-water contamination in the final set of sites studied. The table below displays the frequency of occurrence for five categories of sources. Note that some sites were contaminated by more than one source.

Confirmed or Suspected Source	Cases
Airport/military base or contractor	5
Plating industries	4
Electronic industries	3
Landfills/chemical waste handlers	3
Other industrial	3

In all cases where a source was confirmed, either the use or disposal of solvents or degreasers was mentioned as the cause of ground-water contamination.

The list above suggests the type of industries that should be investigated for potentially hazardous organics use and disposal practices. In the experience of several state officials, wherever TCE has been used in any significant quantity, a problem exists. More specific point sources that were found in follow-up investigations at the above sites were leaking underground storage tanks, dry well/pump disposal of used solvents, and chemical tank or barrel rinse areas. No contamination incidents were reported as the result of one isolated spill, but many cases were reported where continuous disposal took place over several years.

In the dozen cases where a point source was identified, actions were taken to eliminate that source. The organics still contained in the unsaturated zone remain in many cases as non-point sources, contributing to contamination in the saturated aquifer zone with every major rainstorm. Above-ground sources, however, have been controlled and are in most cases being strictly monitored.

Discovery of Ground-Water Contamination

The presence of organic compounds in drinking water wells was discovered by a wide variety of methods in the cases studied. The following table shows how many contamination incidents were detected by each of five methods.

Method of Discovery of Organics	Number of Cases
State/County Monitoring Program	4
Contamination Suspected	4
Accidental Testing	4
Testing for Trihalomethanes	2
Federal Monitoring Program	1

The federal monitoring programs have turned up many cases of organics contamination nation-wide, but these programs were usually involved only indirectly, by heightening awareness of potential ground-water quality problems, in the cases examined in this study. Several incidents of organics contamination discussed in this report were discovered by state monitoring programs, and many more are likely to be discovered as more states begin testing public water supplies. Budget constraints and limited laboratory capacities are major factors hindering state monitoring programs.

Somewhat surprisingly, in several of the water systems studied, synthetic organics were discovered while testing for trihalomethanes. Trihalomethanes are rarely found in well water supplies due to the lack of organic precursors (humic and fulvic acids) in ground water and less frequent chlorination. The four water systems that were suspected of containing organics were tested because of taste and odor complaints or because organics were detected in nearby industrial wells or ground-water supplies.

In four of the fifteen cases studied, contamination of public water supplies by synthetic organic compounds was not particularly suspected. The thought that over twenty-five percent of these cases of ground-water contamination were discovered accidentally is not a comforting one. Unfortunately, no data were available on the frequency of negative test results which could be used to estimate nation-wide trends in contamination.

Prevention of Ground Water Contamination

In few of the cases studied could a simple action have prevented aquifer contamination, since the organics release was not usually confined to a single point source. The cases with leaking buried solvent tanks, Vero Beach and the Great Oaks Water Company, however, could have been easily prevented, if the leaks had been detected either by some simple accounting of the amount of solvent delivered, used, and stored or by occasional pressure tests on the tank systems. The gasoline tank leak in Rockaway Township that spilled thousands of gallons could also have been prevented by either of these methods.

The majority of the cases studied involved the use of thousands of gallons of solvents/degreasers over a five to twenty year period. Several of these sites even halted most operations ten or more years ago, but the organics are still present in ground water in high enough concentrations to cause concern. Of equal concern is the length of time that people in some areas had been drinking organics-laden water. Avoiding problems of this magnitude would have required a complete change-over in handling and disposal methods for chemicals many years ago, rather than any simple preventative steps.

Actions Taken in Response to Contamination

Actions taken in response to the discovery of organic contaminants in drinking water range from Glen Cove's closing wells to Rockaway Township's installation of granular activated carbon adsorption contactors and a packed tower aeration column. Table III-1 displays the immediate, short-term, and long-term actions taken by each system to provide high-quality drinking water to their customers.

The typical response on the part of a water system was to confirm the initial tests that showed the presence of organics, notify the appropriate state health or environmental agency, and close the wells showing any significant amounts (with the definition of 'significant' varying from 0 to 75 ppb) of contamination. The next step was usually to notify the public of the problem and meet with county and state health, state environmental, and any regional agencies with jurisdiction over water quality to plan a coordinated response. By this time, the system might have had to purchase water (at rates ranging from 2 to 5 times normal costs) from neighboring interconnected systems, or implement water use restrictions.

In an ideal response, investigations to trace and control the source of contamination would parallel studies of alternatives for supplying uncontaminated water. These alternatives would usually include drilling new wells or providing treatment by carbon adsorption or an aeration technique. Two important factors enter this decision: the cost and availability of new well sites

TABLE III-1

RESPONSES TO ORGANIC CONTAMINATION

Case	Percent of Water Supply Affected	Immediate Response	Short-Term Actions		Long-Term Actions		
		Close Wells	Purchase Water	Temporary Treatment	GAC	Aeration	New Wells
Bedford	60	Yes	Yes	No	No	No	Yes
Rockaway Township	45	Yes	No	No	Yes	Yes	No
S. Brunswick Township	32	Yes	No	No	No	No	Yes
Garden City Park W.D.	75	Yes	Yes	No	No	Pilot	Yes
Glen Cove	50	Yes	Yes	No	Pilot	Pilot	Yes
Vestal	25	Yes	No	GAC	No	No	Yes
North Penn. Water Authority	33	Yes	Yes	No	No	Pilot	Yes
Vero Beach	92	Yes	Not Possible	No	No	No	Yes
Elkhart	40	Yes	Not Possible	No	No	No	In Planning
Battle Creek	60	Yes	Not Possible	No	No	No	No
Petoskey	100	No	Not Possible	No	No	No	No
New Brighton	90	Yes	No	No	No	No	Yes
Tucson	5	Yes	Not Possible	No	No	No	No
Great Oaks/San Jose	15	Yes	No	No	No	No	No
Lakewood	10	Yes	No	No	No	No	No

and the required quality of the treated water. Since no single numbers have been widely accepted as reasonably safe and attainable levels of contamination, systems often opted for the more certain choice: a new source of water. An engineering contractor usually designed the treatment system or placed the new wells. Except for the companies doing business in carbon systems, most consultants have preferred aeration technologies when drinking water treatment is the chosen alternative.

The investigations into the source(s) of contamination usually involved sampling private wells and drilling monitoring wells to determine the extent and magnitude of organics in ground water. A consulting engineering firm was often used for this step although the state agencies or EPA occasionally provided investigative teams. A scenario frequently observed was the investigator tracing the contaminant plume toward a particular industrial site, but not being able to conclusively prove responsibility for the contamination. In only three of the fifteen cases studied did the suspected culprit cooperate willingly and aid on-site surface or drilling investigations to trace the source. In a few cases no real progress has been made, but some progress has been made in most cases, as shown in the following table.

	Investigations Concluded	Investigations Continuing
No Success in Tracing Sourcce	-	-
One Source Suspected	2	3
One Source Confirmed	4	-
More than One Source Suspected	2	4
More than One Source Confirmed	-	-
	8	7

Health Guidelines

The lack of detailed information on the health effects of organic chemicals in drinking water and the corresponding lack of consistent guidelines were the major problems faced by the states and municipalities in dealing with groundwater contamination cases. Only a few states, such as New York, have gone beyond reviewing the array of health effects numbers published at one time or another in the *Federal Register*. Table III-2 shows the variety of concentrations allowable at certain risk and exposure levels for trichloroethylene, the organic most often detected and used as an indicator of contamination. Not only do health officials have a lack of confidence in this type of risk estimation, but they also have a variety of methods for applying the information. Consequently, as shown in Table III-3, the maximum contaminant levels recommended in state guidelines for trichloroethylene range from 0 to 75 ppb.

The implications of the uncertainties and inconsistencies in health guidelines for organic chemicals found in ground water are major. Most obviously, customers of some water utilities are subject to higher toxic and carcinogenic risks than others. Secondly, the health guideline levels greatly affect actions taken and expenses incurred in protecting water quality. If all the cases studied had been subject to a recommended TCE limit of 75 ppb, half would not have had to take action besides closing a few wells, and five or six water supply crises would have been averted (although public pressure might have forced stricter measures). Thirdly, because of the uncertainties in health guidelines and the possibility of a standard being set, water operators were afraid to take assertive actions, and they were especially hesitant to install engineering control technologies to reduce contaminant levels, for fear of

TABLE III-2

TOXICITY AND CARCINOGENIC RISK GUIDELINES FOR TRICHLOROETHYLENE

EPA Suggested No Adverse Reponse Levels (SNARLs)

Length of Exposure	Concentration in Drinking Water (ppb)
One-Day	2000
Ten-Day	200
Chronic	75

Drinking Water Exposure for Carcinogic Risk

	Concentration in Drinking Water (ug/l)	
Projected Upper Limit Excess Lifetime Cancer Risk	National Academy of Sciences (NAS)	EPA Carcinogen Assessment Group (CAG)
1 in 10,000 (10^{-4})	450	280
1 in 100,000 (10^{-5})	45	28
1 in 1,000,000 (10^{-6})	4.5	2.8

Assuming: Lifetime exposure (70 years) by 70 kg adult, consumption of 2 litres of water per day.

TABLE III-3

SUMMARY OF STATE GUIDELINES FOR TRICHLOROETHYLENE IN DRINKING WATER

State	Location	Recommended Maximum Contaminant Levels for TCE
Massachusetts	Bedford	75 ppb
New Jersey	Rockaway Township	any single VOC-50 ppb, total VOCs 100 ppb
	S. Bunswick Township	33 ppb
New York	Garden City Park WD	any single VOC-50ppb, total VOCs 100 ppb
	Glen Cove	any single VOC-50ppb, total VOCs 100 ppb
	Vestal	any single VOC-50ppb, total VOCs 100 ppb
Pennsylvania	North Penn. Water Authority	originally 4.5 ppb, now 75 ppb
Florida	Vero Beach	0.00 ppm
Indiana	Elkhart	originally 75 ppb, now 45 ppb
Michigan	Battle Creek	minimizing exposure suggested (0 ppb)
	Petoskey	minimizing exposure suggested (20 ppb)
Minnesota	New Brighton	27 ppb
Arizona	Tucson	5 ppb
California	Great Oaks Water Company	5 ppb
Washington	Lakewood WD	no guidelines, handled case-by-case

over- or under-designing. The officials contacted were confident in the capability of treatment technologies to remove organics from drinking water, but were uncertain about what removal efficiencies to specify.

In short, the lack of consistent health guidelines is the major obstacle to state and municipal officials responding to organic contamination of ground water used as a drinking water source. Many different interpretations of health effects information by state officials have confused local water systems and caused great public concern. Section IV elaborates on the need for additional health effects research.

IV. GROUND-WATER CONTAMINATION RESEARCH AND DEVELOPMENT

An important objective of this study was to identify research needs relating to the detection and control of organics in ground water, particularly in aquifers used for public water supplies. This section discusses research needs either mentioned by the municipalities or state organizations or inferred from the case studies. The discussion is organized into five technical and one general area. The areas discussed are the following:

- Analytical Procedures for Monitoring Contaminants
- Determination of the Extent and Source of Contamination
- Engineering Control Technologies
- Aquifer Management Technologies
- Health Effects
- Other Needs

These topics were defined to parallel the areas addressed in EPA ground water research plans.

ANALYTICAL PROCEDURES FOR MONITORING CONTAMINANTS

The analysis of how the presence of organic contaminants in ground water was actually detected in the cases studied, discussed on page III-5, provides some interesting insights. Only one of the fifteen cases was detected through a federal monitoring program, while six cases were detected either accidentally or during voluntary (not required) testing for trihalomethanes. Many water utility officials, especially in the Northeast, were in favor of broadening mandatory testing programs for organics in ground water. These officials were generally of the opinion that many of their neighboring systems had problems with organics but either were afraid to test in the first place because of the potential cost of treatment, or had tested and found organics but chose not to report the test results to the State water quality agency or the public.

The following breakdown shows the laboratories finally used for the majority of the analytical work in each case:

Primary Laboratory	**Cases**
EPA	2
State	6
County	2
Private	5
	15

The quality of EPA labwork was generally reported as quite good but delays in performing analysis were common. As a result, if EPA labs were used, it usually meant that no other alternatives were available or affordable. In several cases, municipalities switched from public to private labs for faster turn-around. The State laboratories were also reported to be consistently competent, but in every case, personnel, equipment, or budgetary constraints slowed response time and limited the number of analyses that could be performed. At Battle Creek, for example, the state health department could only spare a dozen sample bottles every two weeks, so it took many months to determine how many private wells near the public wellfield were also contaminated. Nassau County, New York was the only county studied with organics analysis capability. Since more people live in Nassau County than in several states and since ground water is relied upon almost exclusively for public supplies, it is not surprising that the County Health Department has had the capacity not only to handle virtually all the water quality testing, but to revise and improve several EPA laboratory methods.

All but one of the water systems that turned to private labs for organics analyses faulted the quality of at least one lab used. Especially in the cases detected from 1978 to 1980, reproduceability of test results was poor. Analyzing and reporting extremely low concentrations of organics was also a weak area. Water systems often ended up "shopping around" to find good quality analytical services at a reasonable cost. Fortunately, laboratories performing organics analyses have improved over the past several years, and most of the water systems are satisfied with the quality of recent test results. Split samples are usually taken as a quality control measure. Sampling procedures are not regarded as a technical weakness.

Monitoring of water supplies after an incident of contamination has been discovered is generally not a problem area. Once the municipalities studied detected the presence of organics in their water, frequent monitoring was always instituted to maintain water quality. Three factors usually influenced the decision to monitor frequently: the personal responsibilities felt by water officials, recommendations from the state health agencies, or public concern over the potential health hazards.

In the areas of testing, sampling, and monitoring, several needs were voiced. The first general request was for more funding for equipment and qualified personnel. The second set of requests was organized along more technical lines, summarized in the following points.

- A one-time nation-wide program of sampling finished ground water for organics should be instituted, with priority given to water systems located near large-scale users of industrial solvents. Michigan, for example, has begun a state-wide survey, beginning with the most vulnerable systems in each district, with sampling priorities set by the district engineers familiar with local problems. The national monitoring surveys already performed should be analyzed to isolate common factors involved in organic contamination of ground water, so that priority sampling can begin.

- Several water officials mentioned a need for revised sampling and testing procedures to include more organics. Current standard methods are viewed as time-consuming and expensive, although generally adequate, but they need to be simultaneously expanded and streamlined.

- The development of a general screening method for organics was suggested as a valuable tool by the director of the Michigan Department of Health laboratories and others.

- A frequently heard complaint concerned the reporting of trace amounts of organics. EPA was requested to standardize a policy regarding lower detectable limits to avoid reports of "suspected trace amounts" of a particular contaminant that might not actually be present, complicating investigative efforts and further upsetting the public. Reports of organics present below detectable limits are felt to be unfairly slanted towards implying the presence of a chemical. Research in this area must be associated with the health effects of various organics found in ground water.

- The water utilities who used private laboratories want to see expanded laboratory certification programs. Even state labs could often improve quality assurance programs, although most appeared to be very conscientious about professional standards.

- Sampling procedures were reported as adequate in most cases, but several officials thought that the "trace amounts" of chemicals occasionally reported from analysis were due to cross-contamination during sampling or to ubiquitous compounds present in the laboratory.

- Other minor problems with sampling, especially the difficulty in sampling for volatile organics in deep wells, were brought up as problems, some of which could be remedied by well design.

- Searching for abandoned wells was a problem in about a third of the cases studied. The potential of abandoned wells as hidden sources of contamination, as perforations through confining clay beds, or as additional data sources for aquifer sampling was mentioned several times. The basins containing the Lakewood and Great Oaks water systems, for example, are estimated to contain over 5,000 and 9,000 wells, respectively, but no one knows the exact numbers or locations.

DETERMINATION OF THE EXTENT AND SOURCE OF CONTAMINATION

Several technical topics are addressed under the above heading, including methods for determining the transport and fate of organic contaminants and characterizing the hydrological/geological features of the saturated and unsaturated zones. For purveyors of ground water, these topics are important in both determining the local extent of contamination (necessary for choosing locations for new wells) and for planning measures to prevent the migration of organics to other production wells. These topics are also critical in tracing plumes of contaminants back to their sources.

As discussed earlier, most of the utilities studied had difficulties in outlining the extent of contamination and tracing the source. The cost of putting down monitoring wells in some regions is very expensive, limiting the number of data points available for decision-making. The relative lack of information on the transport and fate of chemicals in the subsurface also hindered investigations. Several utilities, such as the towns of Vestal and Bedford, described their ground-water investigations as "basic" or "textbook," but most faced technical and/or budget constraints. In several cases, such as Lakewood, Petoskey, and Lansdale (North Penn Water Authority), anomalies in the local geology severely complicated efforts to outline the extent and trace the source of organics contamination.

The municipalities studied usually had a ground-water consulting firm, or occasionally the state water quality agency, conduct the actual investigations to determine the extent and source of contamination, and therefore were not directly involved in the technical aspects. Several general areas where the utilities or their consultants did request more research and information are summarized in the following points.

- The most frequent request for research was on the transport, detention, and degradation properties of various organic chemicals in both the saturated and unsaturated zones. Existing information is, at best, fragmentary, and predictions of the mobility and transformation of organic contaminants in ground water are not nearly as accurate as predictions for inorganic compounds.

- Of particular interest are the degradation products, in industrial processes and subsurface, of ubiquitious organics such as trichloroethylene and trichloroethane. Ground-water investigators have a definite need for data relating organic compounds found in low or trace concentrations to those found at higher concentrations, especially to confirm or deny conjectures that only one source of contamination is involved.

- Several ground-water specialists stressed a need to design subsurface sampling investigations around predictive ground-water flow and transport models, rather than to apply models to existing data. The consultants interviewed claimed they occasionally used in-house models, but the time and expense involved in verifying the predictive capabilities of most models were often better spent on pump tests and other forms of data collection. No state agencies involved in determining the extent and source of contaminants in ground water reported using models to predict the behavior of pollutants in ground water.

- Both the parties conducting contamination source investigations and the suspected contaminators asked for the development of standard methods for monitoring well placement and sampling to support or deny charges of polluting an aquifer. "Standard, accepted practices" are required for credible data when municipalities have to go to court to recover damages from alleged sources.

- The capability to conclusively identify a compound found in ground water as emanating from a particular source, by some type of "chemical finger-printing" method, was one area of R&D requested by a few organizations. No one knew much about the technology, but most thought it would save investigative and legal time and money, especially in cases such as the Tucson Airport problem, where more than one source is now suspected.

ENGINEERING CONTROL TECHNOLOGIES

Although only one of the water utilities studied had implemented a full-scale treatment plant, most officials agreed that engineering control technologies were fairly well advanced. In all the cases studied, treatment to remove organic compounds from drinking water was at least considered, and one or two systems may yet install treatment plants. Between the consulting engineers and the lead agency handling each case, enough basic technical information was usually available. These sources credited EPA for performing some very useful research in the field.

By coincidence, at two of the cases studied EPA pilot projects are being conducted. At Glen Cove, New York, pilot studies are being conducted at one contaminated well to compare removal efficiences of resin and granular activated carbon adsorption and air-stripping techniques. Work is also being carried out to test regeneration methods and the effectiveness of regenerated adsorption media. At the North Penn Water Authority in Lansdale, Pennsylvania, a pilot study of in-well aeration techniques is in progress. The potential of this technology was discovered when samples of organic-contaminated water were air-lifted out of wells and found to have reduced levels of volatile organics.

Three types of comments were received about the state of research on engineering control technologies. The first was a request for updated cost information and the publication of more technical data on the major methods of removing organic solvents, mainly granular activated carbon (GAC) adsorption and packed-tower aeration processes. The second request was for more field work and demonstration projects on the techniques already proved in the laboratory. This type of research is necessary to provide design information, costing, and actual removal efficiencies under field conditions.

The third research-related request was for a decision on the levels of contaminants allowable in drinking water so that design specifications can be set. Engineers are afraid of under- or over-designing treatment plants, in the face of uncertainties about what level of organics removal must be obtained to meet health standards. This belief is certainly one reason why more water treatment systems have not been installed. The only beneficiaries of this uncertainty are lessors of temporary treatment systems.

To reiterate, local and state water officials feel that engineering control technologies have been fairly well proven and only require updated process costs and some field demonstrations. The majority of water system operators contemplating treatment are leaning towards some type of packed-tower air-stripping to remove volatile organic compounds. One significant problem is the lack of solid standards or guidelines for organics, which hinder design specifications. Overall, better dissemination of information on technical research and on the GAC and aeration systems currently in use is needed.

AQUIFER MANAGEMENT TECHNOLOGIES

Several technical areas, categorized here as "aquifer management technologies" and separate from the treatment methods generally referred to as engineering control technologies, were also discussed by the officials contacted in the cases studies. Some type of aquifer management was considered in about one third of the cases studied. The technologies discussed here deal with aquifer rehabilitation or with shifting the plume or zone of contamination.

Aquifer rehabilitation, including restoration of both the saturated and unsaturated zones, involves two technologies: either in-situ or surface treatment of the contaminated water and purging the unsaturated area of contamination, combined with removal of the source of contamination. This type of remedial action, although expensive, is sometimes necessary. The third technology under this category involves designing pumping patterns or injection strategies to keep the contaminant plume away from production wells. In most of the cases studied, the water utility pumped contaminated wells to waste to keep organics from migrating to uncontaminated wells.

A definite need exists for research on aquifer rehabilitation technologies. At ten of the sites studied, production wells are or were being pumped to waste (only three water systems or industries treated the contaminated water before discharge), but no plans for reinjection have been approved, and no work has been planned to purge the unsaturated zone. The present literature reflects only a recent interest in this country in restoring water quality in the aquifer, so specific needs cannot be easily addressed. From the cases studied, only the general need for more research on this topic can be reported. A major reclamation project, however, is being planned at the Tucson Airport site that should provide useful data.

As mentioned, two-thirds of the systems studied decided to pump contaminated production or montoring wells to waste, usually to prevent migration of the contaminant plume rather than to restore the aquifer. Plans to reinject treated water were considered at four or five sites, but rejected by EPA or the lead agency because of the fear of altering aquifer flow patterns and further dispersing the contaminant plume. At Battle Creek a study by USGS investigated the possibility of injecting water between the city's well field and the source of contamination to create a mounding effect to prevent further migration of contaminants toward the well field.

In summary, although decisions to pump contaminated wells to waste are rarely controversial since current practices are not being changed, the decisions are often made after considerable delay and without sufficient information. Few experts seem to have enough confidence in injection and monitoring techniques to reinject treated water. Enough interest has been expressed, however, by the states and municipalities to justify increasing research on aquifer management technologies beyond hazardous waste site cleanup and prevention. Information on the costs of aquifer rehabilitation techniques relative to other alternatives for restoring water supplies is especially needed.

HEALTH EFFECTS

More than any other area, health effects research was unanimously suggested as the topic on which municipalities, states, and the Regions most desperately need EPA assistance. Only the federal government, and possibly a few states, have the capability to carry out the toxicity and carcinogenicity studies required to provide the data for determining the relative hazards of various contaminants at different levels of concentration. In making decisions about ground water quality solely to protect public health, optimum choices simply cannot be made if the major criterion is unknown.

First and foremost, water agencies need more information on the acute and chronic health effects of the most common organic contaminants. Realizing that some of this research is completed or in progress, the next need that must be met is reporting the results on two levels. The major effort at distributing health effects information should be concentrated on the usual technical reports intended for scientists and health specialists to assist in their decision-making responsibilities. The second level of reported results needs to be in a version that the general public can understand. The misinformation and misconceptions common to most of the cases studied created many difficulties for local officials who often were not able to explain to citizens what the health effects of drinking contaminated water might be. In support of regulatory development and to assist officials in the field, the completion of health effects research, especially on the organics prevalent in ground water, is essential. The need to then provide understandable information to the public must be emphasized.

A somewhat surprising finding of this study is that the majority of the dozens of local and state water quality and health officials interviewed were in favor of nation-wide standards for the volatile organic compounds most frequently encountered. In a dramatic turnabout since the proposal of maximum contaminant levels for trihalomethanes, almost all those involved in the case studies favored standards for organics, for several reasons. The two reasons heard most often were to protect the public health as much as possible, and to finally be able to supply water designated as "safe" by the federal government, for the comfort of water officials and especially to satisfy the public's concerns.

In about half of the cases studied, the existing SNARLs by EPA or the estimated increased carcinogenic risk levels determined by NAS were not understood. The difference between the SNARLs and risk level numbers was one of the problems: many systems did not differentiate between the two sets of numbers proposed for several organics, and even used them interchangeably. In the New Jersey cases, a wide range of "health numbers" were recommended to different municipalities. In the Elkhart case, every agency involved had their own number, each of which had been published somewhere, for allowable levels of trichloroethylene in drinking water. It is imperative that a consistent policy for carcinogenic risk assessment be developed and that a consistent set of health advisories on the most common organics be issued under this policy.

Whether nation-wide maximum contaminant levels (MCLs) are issued for organic compounds in drinking water or not, recommended maximum contaminant levels (RMCLs) and supporting health effects information are necessary for municipalities to plan a response to organic contamination in ground-water supplies and for the states to provide a basis for regulatory decisions. The fact that the need for consistent health effects information was the highest priority request in the cases studied in this report must be underscored.

OTHER NEEDS

Across the technical areas discussed above, several general requests were made related to EPA research and development. The three broad areas where assistance would be helpful were in reducing the costs of dealing with organics in ground water, disseminating more technical information, and in providing more trained expertise. Advances in these general areas would improve overall response to the ground-water contamination problem.

First of all, cheaper analytical methods, less costly drilling and monitoring techniques, and more efficient and economic treatment technologies are items that everyone in the ground-water field would, of course, like to see. The need for cheaper, more efficient methods is hard to dispute.

Equally important and more easily attainable is the goal of improving the transfer of technical information. The major sources of technical information on topics related to ground-water contamination, for the municipal water systems studied, were the state health and environmental agencies, EPA program staff, ground-water consultants, and technical journals and conferences. No water officials contacted mentioned the EPA Clearinghouse for Ground Water Models or the Ground Water Information Center as sources used for information. One of the primary sources in EPA of technical and health effects information was through the Office of Drinking Water's Criteria and Standards Division, which was found helpful in several of the cases. Several ground-water consulting firms have organized successful conferences to educate state and local personnel about methods of detecting, monitoring, and resolving problems with contamination of ground-water supplies. This type of conference seems highly valuable, and EPA should consider supporting similar programs. However it is accomplished, improving the transfer of technical information should be a high priority.

Especially in the state agencies and Regional offices, the lack of qualified personnel was identified as a common problem. The few toxicologists and hydrogeologists employed by the health, water, and environmental agencies are spread very thinly. Where laboratory facilities for organics analysis are available, qualified technicians often are not available, or are severely overloaded due to the drastic recent increases in sampling. Traditional engineering training in water and waste water treatment is proving to be insufficient as new health hazards (carcinogens) are turning up in water sources formerly considered pristine. Some type of updated training in the skills required to deal with ground-water contamination would be an interim solution to a problem that over time must be addressed on a broader scale.

V. CONCLUSIONS

The majority of effort in this study was concentrated on gathering information for detailed studies of ground-water contamination cases. The full case studies should be a valuable resource for those setting research and program priorities in the field of ground water. An analysis of characteristics common to most of the cases provides insights about potential trends in ground-water contamination.

Organic solvents were, by far, the most frequently discovered contaminants, with trichloroethylene reported as the most ubiquitous organic compound detected, appearing in eighty percent of the cases. Trichloroethylene is becoming the indicator compound for monitoring and treating organics in drinking water. State monitoring programs and testing initiated by suspicions of contamination from likely sites originally led to the detection of the contaminants in the majority of contamination incidents studied, but forty percent of the cases were discovered accidentally or while testing for trihalomethanes. In terms of identifying high-priority sites, private and military aerospace industries and airports were most frequently associated with organic contamination incidents, followed by landfills and chemical waste handlers, electronic companies, and plating industries. Specific point-sources were usually above ground or buried solvent tanks, solvent baths, or old disposal wells or dump areas.

The case studies explain, in detail, the specific actions taken in response to the detection of organic chemicals in drinking water supplies. Overall, most municipalities responded fairly well to the situation, and no major mistakes were made, but some problems were common. The most frequently encountered problem was a lack of understandable information on the health effects of the organic compounds detected. Decisions on water supply alternatives and treatment options were very difficult to make without solid health guidelines, so most systems simply closed the contaminated wells and looked for new wells.

The second part of this study focussed on the research needs of states and municipalities confronted with organic chemical contamination of ground-water supplies. The research needs discussed by the water, environmental, and health agencies were usually very general, but a few deficiencies in technical information were commonly mentioned.

By far, the major obstacle in choosing alternative responses to the problem of organics in ground water was the paucity of health effects information and guidelines. Requests for increased research and dissemination of information on the health effects of common organic compounds were virtually unanimous. Testing, sampling, and monitoring were technical areas with fewer weaknesses. Engineering control technologies for removing organics from drinking water were considered to be fairly well advanced, although more field demonstrations were requested. Aquifer management techniques also need more refinement before rehabilitation of aquifers will be commonly accepted. Few specific research needs other than those discussed above were mentioned by the state and municipal officials contacted.

Finally, the in-depth case studies, data on incidents of ground-water contamination, and source lists of the persons contacted at the many agencies involved in these cases provide a firm basis for further investigations. This report is intended to provide insights about the common problems and research needs of states and municipalities dealing with ground-water contamination. As such, it presents the necessary information to examine particular aspects of the problem in greater detail.

APPENDICES

APPENDIX A: Initial Survey Results

APPENDIX B: Sample Interview Questions

APPENDIX C: Complete Case Studies

Bedford, MA
Rockaway Township, NJ
South Brunswick, NJ
Garden City Park, NY
Glen Cove, NY
Vestal, NY
North Penn Water Authority, Lansdale, PA
Vero Beach, FL
Elkhart, IN
Battle Creek, MI
New Brighton, MN
Tucson, AZ
Great Oaks Water Company, San Jose, CA
Lakewood, WA

APPENDIX D: List of Contacts for Each Case

APPENDIX A

INITIAL SURVEY RESULTS

REGION I

(77 Cases)

Case	Contaminants	Description of Extent of Drinking Water Problem	Additional Information
CONNECTICUT			
EPA "100 Worst" Site Laural Park Landfill, Naugahiek	Organics	Possible DW problem. Confirmed GW contamination.	
MAINE			
McKin Company Landfill, Grey	Trichloroethane Trichloroethylene Acetone	16 private wells affected. Traces found in town's public water supply.	Ongoing investigation. Suspected source - waste oil lagoon.
MASSACHUSETTS			
*Bedford	TCE, Dioxane	4 wells that supply 80 percent of Bedford's water supply.	Discovered 1978. Bedford then purchased water from 4 nearby communities. One town later had to close its wells due to TCE.
NEW HAMPSHIRE			
Nashua Sylvester's, Gilson Rd	Organics	Private well users had to connect to public supply. Contaminants leaching into SW supply that is used downstream for DW for Lowell, MA. Unlikely to affect Lowell water quality.	Superfund case. Successful lawsuit against waste disposal company.
VERMONT	No major cases reported. State has commissioned study of ground-water contamination problems. Results expected by year end.		
RHODE ISLAND	No major cases of organics contamination.		

REGION II

Case	Contaminants	Description of Extent of Drinking Water Problem	Additional Information
NEW JERSEY	In 1980-81 4.2 percent of New Jersey wells tested (670 of 16,000). Of these, 111 had organic contaminants, 31 had pesticides, 29 had toxic metals, and 11 had to be closed. Some problems in state discovered through regular testing; others via cancer testing program.		
Allendale	Tetrachloroethylene	3 municipal wells affected. Drilled two new wells.	
Fairlawn	TCE	Municipal wells affected. Increased outside purchase.	
Mahwah	Trichloroethylene	Municipal well closed. New well proposed.	
Camden	Trichloroethylene	Municipal well closed.	
*Rockaway	Trichloroethylene	2 of 3 municipal wells closed 1980. Third well later contaminated by di-isopropyl ether and methane chloride.	City declared emergency. Installed activated carbon absorption filter system.
Picatinny Arsenel	Trichloroethylene	Base's DW wells contaminated.	Don't want to clean up.
EPA's "100 Worst" Sites D''mperio Property Hamilton Township, Atlantic County	Trichloroethylene, Toluene, Hexane	Proven GW contamination. About 3,000 people in area use GW for DW. Primarily private wells.	Monitoring wells installed.
EPA's "100 Worst" Sites Goose Farm, Pijack Farm Spense Farm, Upper Freehold, Plumstead Township, Ocean County	PCB, Chlorinated Solvents	GW contamination. Municipal wells near sites. Township relies on contaminated acquifer for DW.	Possible Superfund site. Section 311 CWA action to clean up.
Jackson Township	Benzene, Toluene, TCE, Ethylbenzene, Acetone	146 private wells contaminated by landfill. Water trucked in. Residents claim health damaged.	Long standing problem.
*South Brunswick	Trichloroethane Dichloroethylene Trichloroethylene	One-third of pumping capacity for the township's 18,000 customers affected.	Contaminated well pumped to waste, new well drilled.
NEW YORK	Many problems discovered through regular testing; most organics contamination thought to be due to industrial sources. Wells generally not closed down if alternative DW not available. Widespread TCE problem in Long Island.		

REGION II
(Continued)

Case	Contaminants	Description of Extent of Drinking Water Problem	Additional Information
NEW YORK (Continued)			
Endicott, Broome County	Organics	Municipal well closed.	
*Vestal, Broome County	TCE	One of three municipal wells closed.	GAC used temporarily until new well drilled.
Johnstown, Fulton County	Organics	Municipal well closed.	
Caledonia, Livingston County	Organics	Municipal well closed.	
Brewster, Putnam County	Organics	Municipal well closed.	
Queens	Organics	Municipal well closed.	
Suffern, Rockland County	Organics	Municipal well closed.	
Nassau County	Trichloroethylene, Tetrachloroethylene, 1,1,1 Trichloroethane	At least 13 municipal wells closed since late 1970s.	Major problem in region.
Suffolk County	Trichloroethylene, Tetrachloroethylene, 1,1,1 Trichloroethane	At least 16 municipal wells closed since late 1970s.	Major problem in region.
Suffolk County	Aldicarb	2 municipal wells, 24 private wells closed. Estimate another 650 private wells contaminated.	Pesticide had been used on 22,000 acres of potatoes.
*Garden City Park	Tetrachloroethylene	3 of 9 wells contaminated, cannot meet peak demands.	New well drilled, water usage restrictions implemented.
*Glen Cove	1,1,2 Trichloroethylene Tetrachloroethylene	4 of 7 wells closed due to contamination.	Bought water and added new wells to meet demand.
Spring Valley Water Co.	TCE, Perchloroethylene	Six wells closed. Company serves 4 cities in Rockland, about 10% of area DW supply.	
EPA's "100 Worst" Sites			
Batavia Landfill, Batavia	Solvents, Phenols	Confirmed GW contamination. About 6,000 people in area rely on acquifer for DW.	
Old Bethpage Landfill, Oyster Bay	Toluene, PVC, PCB	Contaminated GW in heavily populated area that relies on GW for all DW. Near state park water well.	

REGION II
(Continued)

Case	Contaminants	Description of Extent of Drinking Water Problem	Additional Information
Olean	TCE	3 wells used for about 80 percent of DW supply closed. Numerous private wells affected.	Received Superfund money.
Elmira, Chemung County	PCB, 1,1,1 Trichloroethane, Arsenic, Cadium Trichloroethylene	Municipal well closed. private wells within half mile of contamination source (Facet Enterprises).	

REGION III

Case	Contaminants	Description of Extent of Drinking Water Problem	Additional Information
DELAWARE			
Smyrna	TCE	Public supply affected. Used increased filtration and aeration to reduce levels.	Problem discovered in 1970.
EPA's "100 Worst" Sites New Castle, Delaware Sand & Gravel, Llangollen Army Creek Landfill	TCE, 1,2 Dichloroethane Trichlorofluromethane	Contaminated acquifers used as DW supply for 100,000 people.	EPA has followed case since 1974. State filed lawsuit in 1976.
PENNSYLVANIA	Numerous cases involving private wells.		
*North Pennsylvania Water Authority	Trichloroethylene Tetrachloroethylene	Had to close seven of fifty wells for excessive levels of TCE, one well for tetrachloroethylene.	Bought water and increased pumpage from good wells. GAC system installed.
EPA's "100 Worst" Sites Butler Tunnel, Pittson	TCE, Toluene, Xylene	Contaminated GW discharging into SW near Danville water treatment plant, which provides water for 7,500 people.	
Hranica Landfill, Buffalo Township, Butler County	PCB, Lead, Solvents	Contaminated GW discharging as springs. Springs used by Clearview Water Supply Company to service 1,000-3,000 people.	Landfill closed at state request in 1973. State negotiating with landfill operator.
Lindane Dump, Harrison Township	Lindane	Contaminated GW discharging into Allegheny River near intake used by Clearview Water Company.	Landfill now a public park. Company submitting clean-up plan to EPA.
Lord-Shope Landfill Girard Township	Solvents	GW contamination near DW wells serving 3,000 people.	
VIRGINIA	No major cases of organics contamination reported.		
WEST VIRGINIA	No major cases of DW contamination by organics reported.		
MARYLAND	Few contamination incidents reported thus far.		

REGION IV

Case	Contaminants	Description of Extent of Drinking Water Problem	Additional Information
FLORIDA	Many problems throughout state. Many problems do not affect DW supplies yet but should be source of future water supply problems. Major testing program should provide new information by September 1982.		
East Drive Wellfield, North Miami Beach	Organo-Sulfur Compounds Volatile Organics	No single source of contaminants located. Treated water.	
U.S. Naval Air Station, Jacksonville	Organic Solvents, Toxic Metals, PCB	Contaminant plume moving toward public water supply well 1,200 ft. down gradiant from disposal area.	
*Vero Beach	TCE, Vinyl Chloride	Discovered 1978. Public water supply contaminated one well closed.	Source loated at storage tank owned by Piper Aircraft.
Melbourne	Cadmium, Cyanide, Fluoride, TCE	Port Malabar subdivision well field is contaminated.	
West Palm Beach	TCE	Affect private DW supply of 7,000 employees of Pratt & Whitney Aircraft.	Actions to identify and correct problem called a success.
EPA's "100 Worst" Sites			
Whitehouse, Jacksonville	Phenols, other VOCs	Several sites. Contaminants threaten a number of private wells.	
58th Street Landfill, Miami	Organics	Leachate plume has extended into cone of influence of Preston Hialeah well field, Miami's major supply source.	
Miami Drum Service, Miami	TCE, Perchloroethylene	GW contamination source 750 ft./45 days travel time from newly developed water supply for Miami.	
NORTH CAROLINA	Problems occuring along the coast with septic tanks. No problems reported with public wells.		
SOUTH CAROLINA	Only major case is involved in a lawsuit.		

REGION V

Case	Contaminants	Description of Extent of Drinking Water Problem	Additional Information
INDIANA			
EPA "100 Worst" Sites Fischer-Calo Chemicals, LaPorte County	Organics	Potential DW problem. Well for Kingsbury Utilities Co. is within half mile of site. Residences, trailer park and industrial park, on which rely on GW for DW, are within 1 mile of site.	
*Elkhart	TCE	City's largest well field affected.	Interceptor well drilled to prevent spread of plume.
MICHIGAN	400-500 known cases of GW contamination. Of these 250-300 pose health hazard.		
*Petosky	TCE, CIS-1,2 Dicholoroethylene	1 municipal well affected. Can't close since sole source of DW for community. Source unknown.	Found during regular testing for trihalomethane.
Charlevoix	Trichloroethylene	One municipal well.	Tested because of findings in Petrosky.
Kalamazoo	TCE	3 wells in public well field.	
*Battle Creek	TCE, Other VOCs	13 municipal wells closed. Private wells affected. Private well users advised to hook up to municipal supply, but it has limited capacity.	Accidental discovery near a landfill.
Clare	TCE, CIS-1,2-Dichloroethane	2 of 3 public wells contaminated. Use treatment, helps reduce TCE but does nothing for CIS.	Testing performed when other problems found.
Jackson Lake	CIS-1,2-Dichloroethane	6 of 9 wells in municipal well field contaminated.	
MINNESOTA			
*New Brighton	TCE	5 of 6 municipal wells contaminated. 5 of 6 wells at ammunition plant contaminated. 2 of 3 wells at trailer park contaminated. Many residential wells contaminated.	3 wells closed, looking for funding for new water source.
EPA's "100 Worst" Site Oakdale Dump Site, Oakdale	Organics	Two community wells and number of private wells closed.	3M did the dumping.

REGION V
(Continued)

Case	Contaminants	Description of Extent of Drinking Water Problem	Additional Information
OHIO			
Zanesville		3 of 14 municipal wells had to be flushed because of contamination.	Shallow wells near bank filter river water.
WISCONSIN			
Porteus County	Aldicarb	Wells serving mobile home park contaminated.	

REGION VI

Case	Contaminants	Description of Extent of Drinking Water Problem	Additional Information
NEW MEXICO			
Albuquerque	Benzene	Wells in public supply field contaminated. Under investigation.	
OKLAHOMA	No known major cases of organics contamination.		

REGION VII

Case	Contaminants	Description of Extent of Drinking Water Problem	Additional Information
KANSAS	Several major cases of inorganic DW contamination.		
Park City	Oil Products	Products pipeline ruptured. Two municipal wells abandoned.	
EPA's "100 Worst" Site Arkansas City Dump, Arkansas City		GW contamination. Possible DW problem since located upgradient from local rural water district. Under investigation.	
MISSOURI			
EPA's "100 Worst" Site Ellisville	Organics, Pesticides, Solvents	Some well contamination discovered. Site is situated in Caulks Creek watershed area. Investigation continuing. May only affect private wells.	

REGION VIII

Case	Contaminants	Description of Extent of Drinking Water Problem	Additional Information
COLORADO	12-13 public systems have long standing high nitrate concentration problems. No major organics problems with public supplies reported.		
NORTH DAKOTA	Problems with arsenic and leaching in coal mining areas. No major public DW supply contamination incidents involving organics.		
MONTANA	No major cases involving organics in DW supplies.		

REGION IX

Case	Contaminants	Description of Extent of Drinking Water Problem	Additional Information
ARIZONA			
Citrus Growing Area	DBCP	10-20 private wells, 1 municipal well contaminated.	
*Tucson	TCE	5-6 municipal wells closed. Reopened in 1980 and then closed again. Discovered when screening for THM.	May be from Aerospace plant. State proposes treatment plan.
Phoenix	TCE	Two municipal wells closed. Study of GW underway.	Septic tank-related.
Scottsdale	TCE	Two municipal wells closed. Also affects irrigation wells.	Septic tank-related.
CALIFORNIA			
San Gabriel Valley	TCE	39 municipal wells closed which served 400,000 people in 13 cities. Many now reopened and used with carbon filtration.	Industrial source
Santa Monica	TCE	2 wells that had been closed were reopened when it was discovered the replacement water was contaminated too.	
San Francisco Area	DBCP	Widespread private well contamination.	Proposed class action suit against 90 manufacturers.
San Mateo, Santa Clara, and Alameda Counties	TCE	One municipal well closed. Contamination uncertain. Residents charge health damaged, including birth defects. 400 companies required to test GW at their sites. 160 municipal wells undergoing testing April-May 1982. Private well owners urged to get water tested.	County plans to draw up hazardous waste regulations.
Santa Maria	PCB	State health department testing water.	
San Jose	TCE	One well of investor-owned utility is highly contaminated. Complex aquifers affected.	Well is pumped through filtration to storm sewer. Industrial source is cooperating with monitoring and clean up.
NEVADA	No major organic contamination problems reported.		

REGION X

Case	Contaminants	Description of Extent of Drinking Water Problem	Additional Information
IDAHO			
Coeur d' Alene	Gasoline	Municipal well closed, but later reopened.	Source: leak in buried storage tank.
OREGON			
Lane County	Septic Tank Cleaners, Biological	Community well abandoned. Residents plan to develop treatment.	
Rockaway	Septic Tank Cleaners, Biological	Municipal wells contaminated, treatment planned.	
WASHINGTON	Numerous reports of GW contamination effect on DW supplies not yet proven.		
Yakima	Organics	160 wells (40 percent of 800 tested) are contaminated. Health department recommends residents hook up to public system or drill deep community well.	
Tacoma	Organics	Very large problem involving several sources. South Tacoma acquifer appear to be contaminated.	
*Lakewood	TCE Tetrachloroethylene 1,2-Dichloroethylene	Two wells with high concentration closed, now cannot meet summer demand.	Many agencies involved in pinpointing source of contamination.

KEY:
GW - Ground Water
DW - Drinking Water
"100 Worst" Site - On EPA's list of 100 most dangerous hazardous waste sites.

APPENDIX B

SAMPLE SURVEY QUESTIONS

A. GENERAL INFORMATION ABOUT CONTAMINATION PROBLEM

1. When was contamination discovered?

2. What contaminant levels are involved?

3. What is the likely source of contamination?

4. How extensive is ground-water contamination?

5. How many wells are currently or potentially affected?

6. What has been/is being done?

7. What was the chronology of events and who has been involved?
    - Water utility
    - Municipal government
    - County health department
    - State health department
    - State EPA
    - Regional EPA
    - Industry
    - Consultants

B. GENERAL INFORMATION ABOUT THE WATER SYSTEM

1. How many persons are served by the water system?

2. Is the system public or private?

3. What percent of supply is from ground water?

4. What treatment methods are used?

5. How many wells, what capacity?

6. What are total production capacity, average production, peak demand?

C. DETECTION OF ORGANICS

1. How was the problem originally discovered?
2. When was the problem first suspected?
3. Who initiated testing for organics?
4. When was contamination by organics confirmed?
5. What organics were tested for?
6. What organics were detected, in what concentration, in how many wells?
7. How long might problem have existed?
8. Are any other problems suspected?
9. Might nearby untested sites also be contaminated?
10. How much did testing cost?
11. Who bore the costs?
12. Did the required expense delay the decision to test?
13. Who performed the tests?
14. How were they selected?
15. Were the service, turn-around time, test quality, and reports satisfactory?
16. How confident are you of the results?

C. DETECTION OF ORGANICS (Continued)

17. What local, state or regional organizations were involved in detecting organics in the ground water, and what roles did they play?

18. Did any industry representatives or consultants become involved?

19. What action was initiated on the basis of test results?

20. What organizations were notified?

21. Was the public notified? How?

22. Would better technical information, equipment, or training have been helpful?

23. In retrospect, what were the major problems in detecting organic contamination?

24. General comments.

D. EVALUATING SCOPE OF CONTAMINATION PROBLEM

1. What actions were taken to determine the scope of the problem?

2. What testing or monitoring programs were considered?

3. If such programs were set up, give details on frequency, location, etc.

4. How far is the source of contamination from affected wells?

5. What is the soil type?

6. Do you have any indication that the contamination is spreading?

7. What is the depth and areal extent of the aquifer?

8. How long has the source been contaminating ground water?

9. Are other wells threatened?

10. What other waste dumps, landfills, or industrial sites are nearby?

11. Do you expect any more of the same or other contamination to occur in the future?

12. Who was contacted for assistance in this stage?

13. Who had responsibility for this stage?

14. What local, state, or regional organizations became involved in evaluating the scope of the contamination problem, and what roles did they play?

D. EVALUATING SCOPE OF CONTAMINATION PROBLEM (Continued)

15. Did any industry representatives or consultants become involved?

16. What did follow-up testing and/or monitoring and/or other actions cost?

17. Who bore the costs?

18. Did you feel sufficiently informed as to what to look for?

19. Were testing techniques, equipment, technical expertise, timing, or costs constraints at this stage?

20. Was the public involved in evaluating the scope of contamination? How?

21. Were government officials involved? How?

22. Do you feel the scope of the contamination problem was adequately determined? With what certainty?

23. General comments.

E. RESPONSE TO PROBLEM

1. What action was finally taken?

2. What options were considered?

3. What factors seemed important?

4. What parties were consulted in arriving at a decision?

5. What other state, local, or regional organizations eventually became involved in responding to the drinking water problem, and what roles did they play?

6. Did any industry representatives or consultants become involved?

7. What health information was considered?

8. Were SNARLs used in choosing a response?

9. Were they understandable?

10. Did state or municipality have any applicable regulations or guidelines?

11. Would regulations (MCLs) rather than guidelines (SNARLs) be helpful in deciding on treatment?

12. How were potential changes in regulation considered?

13. Was the time frame of response critical?

14. What was the final cost of resolving the problem?

15. What alternatives for funding were examined?

E. RESPONSE TO PROBLEM (Continued)

16. Who bore the costs?

17. Were technical expertise, treatment technologies, or information on health effects constraints to decision-making?

18. Was the public involved in responding to the problem? How?

19. Were government officials involved? How?

20. Are you satisfied with the resolution of the problem?

21. In retrospect, where could more assistance have been helpful?

22. What were the major problems in responding to the problem?

23. General comments.

APPENDIX C

CASE STUDY REPORTS

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FORMAT FOR CASE STUDY REPORTS

SUMMARY

BACKGROUND INFORMATION

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ACTIONS TO PROTECT WATER QUALITY

CURRENT STATUS

INSTITUTIONAL INVOLVEMENT

HEALTH GUIDELINES

CONCLUSIONS

ABBREVIATIONS

DBCP: dibromochloropropane

DCE: dichloroethylene

DIPE: diisopropyl ether

GAC: granular activated carbon

MERL: EPA Municipal Environmental Research Laoratory

MTBE: methyl tertiary butyl ether

NAS: National Academy of Science

PCE: tetrachloroethylene

SNARL: "Suggested No Adverse Reaction Level"

TCA: trichloroethane

TCE: trichloroethylene

VOC: volatile organic compound

UNITS

gpm: gallons per minute

mgd: million gallons per day

mg/l: milligrams per liter

ppb: parts per billion

µg/l: micrograms per liter (roughly equivalent to ppb)

CASE STUDY REPORTS

TOWN OF BEDFORD
MASSACHUSETTS

SUMMARY

Over the past several years, the Town of Bedford has experienced a substantial water supply shortage as local growth has surpassed the municipal water system's capacity. The shortage was seriously compounded when two synthetic organic compounds were accidentially discovered in the finished water. Four of nine wells were found to be contaminated with trichloroethylene (500 ppb) and trichloroethane as well as dioxane (2100 ppb). The State then recommended closing the wells.

Bedford responded to the crisis in several other ways as well. Water use bans, changes in water charge rate structure, and purchases of water from neighboring systems were the short-term measures employed. Efforts directed toward long-term resolution of the problem included acceleration of an ambitious exploration and development program for new wells and investigations into halting the discharge and leaching of contaminants from the industrial source. Bedford is currently testing new wells but still will not be able to meet water demands for several years.

BACKGROUND

The Town of Bedford supplies water to a residential population of approximately 11,000 residents and a total employment population of about 24,000. Bedford's water comes from two sources: indigenous wells and external connections. Nine wells supplied about 75 percent of the town's water requirements, with the balance purchased from neighboring systems. Unfortunately, the four wells that became contaminated with volatile organic chemicals provided almost two-thirds of the indigenous supply. Average daily demands are about 1.75 MGD, with correspondingly higher summer peaks.

DISCOVERY OF THE CONTAMINATION PROBLEM

The discovery of organic chemicals in Bedford's drinking water was completely accidental. In May 1978, an engineer who lived in Bedford tested his water as preparation for a paper he was writing. Relatively high levels of organics showed up in his test, so he called town officials. When the town became aware of the problem, officials closed the wells and notified the state Department of Environmental Quality Engineering (DEQE). DEQE tested the water to confirm the presence of organics and agreed with the decision to close the wells on June 2, 1978. Besides 500 ppb of trichloroethylene and 2100 ppb dioxane, the DEQE analysis showed that dichloroethane, bromodichloromethane, and traces of chloroform were present in four of Bedford's nine wells.

ACTIONS TO PROTECT WATER QUALITY

Massachusetts generally follows the EPA SNARLs for allowable levels of organic contaminants in drinking water supplies. When dioxane was found, DEQE called EPA for more information. EPA suggested a maximum contaminant level of 20 ppb for dioxane. Based on the guidelines, DEQE and the Board of Health recommended closing well Nos. 3, 7, 8, and 9.

Besides closing the contaminated wells, Bedford took several other measures to combat the problem. To reduce water consumption the town instituted water bans such as those used previously during summer months. Bedford also changed the price structure for drinking water from a flat rate to an ascending block rate, which discourages use.

To meet existing water demands Bedford made arrangements to purchase water from several neighboring interconnected water systems. This solution is only temporary because purchasing the water at retail is quite expensive ($1,400-1,600/day) and several of the neighboring systems are experiencing water quality problems themselves.

The Town of Bedford expects to spend $3 to 4 million on an exploration and resource development program to replace and expand the municipal water supply. Another $1.2 million is expected to be spent on treatment and filtration to remove iron and manganese. The long-term plan must now provide about 1 MGD to meet current restricted demands and may have to provide as much as another 4 MGD to meet expected 1990 demands. A study by Bedford's consulting engineers has identified several potential sites for new wells. The two most promising sites may provide enough water for short-term demands, but high levels of iron and manganese have required expensive treatment technologies. The search for new water supplies is continuing.

In the fall of 1978, Bedford contracted with a consulting firm, Camp, Dresser, and McKee (CDM), to determine the extent and magnitude of aquifer contamination, pinpoint the source(s), and outline actions the town could take. Several of the industries suspected of causing the contamination also hired their own consultants.

The CDM report, which cost Bedford $130,000, recommended three general courses of action: a program to flush the aquifer, investigations into treatment methods, and development of alternative water supplies. A plan to pump three contaminated wells to waste in the Shawsheen River was eventually approved by the Massachusetts Department of Environmental Quality Engineering and EPA, but pumping has not yet started. Treatment methods to control the levels of organics in drinking water have not been extensively investigated. Developing alternative water supplies has been made a high priority, and a major program in that area is continuing, as discussed previously.

Efforts to pinpoint the source(s) and define the extent of contamination have had mixed results. The town and DEQE have been successful in isolating several point sources. Programs of test well drilling and sampling have provided information to develop subsurface descriptions of lenses of contamination associated with various industrial sites. The source of dioxane was not difficult to trace since only one firm in the watershed used the chemical. In most cases, actions to prevent further contamination and continued monitoring have generally been adopted, and litigation has been undertaken by the town against the alleged contaminating companies to assign legal responsibility for remedial measures. In a few other cases, multiple sources have confused the situation and emphasized the vulnerability of the aquifer to accidental contamination.

CURRENT STATUS

At present, Bedford is still involved in litigation against an alleged contaminator. The affected wells remain closed. A NPDES permit was received to pump contaminated water to the Shawsheen River, but pumping operations have not yet begun. The Shawsheen River well field has been rehabilitated to clean out iron and manganese deposits, bringing the wells back up to original capacity. At the Concord River site, three new wells have been drilled, but the treatment plant to remove exessive levels of iron and manganese has not been completed.

INSTITUTIONAL INVOLVEMENT

The Massachusetts Department of Environmental Quality Engineering, the agency with primacy over drinking water in the state has been the nominal lead agency in the Bedford case. DEQE has a good staff of hydrologists, geologists, and engineers supplemented by a toxicologist and an analytical laboratory. A recently approved bond issue has given DEQE $10 million for funding investigations and remedial actions at contamination sites. Financially, the state is now very well equipped to deal with organics problems.

The Town of Bedford has also been very active in the contamination case, assisting in the preliminary industrial survey and contracting with CDM to trace the sources of the volatile organics and dioxane. According to the state, the Bedford case was fairly straightforward, but the town's budget constraints hindered efforts to find and control the sources.

The other major actor in resolving Bedford's organics contamination problem was Camp, Dresser, and McKee, the town's water consultants. The only real difficulty CDM had during their sampling and monitoring well program was with inconsistent analytical results from various labs. This situation changed as the labs improved quality control, although some analytical testing was shifted to the state labs.

HEALTH GUIDELINES

Although the Massachusetts Department of Health has some jurisdiction over water systems, the Department of Environmental Quality Engineering has been awarded primacy for the state's drinking water program and wields the overall authority. As mentioned above, DEQE usually uses the EPA SNARLs as a basis for allowable levels of organics in water supplies. At 75 ppb for trichloroethylene and somewhere between 300 and 1000 for trichloroethane, the SNARLs are considerably higher than the health guidelines in most states.

A DEQE offical stated, however, that although the state has urged several water systems to place previously-contaminated wells back into service, no water utility is willing to take responsibility for pumping even relatively low levels of organics into the water system. In more than one case, wells with total organics levels below 10 ppb are still not being used.

CONCLUSIONS

Although the Bedford incident is presently considered to be a relatively straightforward, basic case, in 1978 it was not viewed as such. At that time, few persons had had much experience in dealing with organics in ground water, and no EPA guidelines were available. Where standard procedures for sampling, drilling, and analytical work are now generally accepted, little guidance was then available. EPA's recommended techniques generally have been considered as good in terms of quality control and legally-defensible data, but time consuming.

Several technical and policy areas have remained as weak points. One technical problem is that while plenty of information was avilable on trihalomethane and volatile organic removal techniques, CDM was unable to find any methods for removing dioxane from water. Research to develop treatment techniques for various classes of related compounds was suggested as one area where EPA assistance is critical. Officials indicated there is a need for greater consistency between regions in terms of acceptable aquifer cleanup techniques, improved health effects information, and better coordination at the EPA regional office, where frequent turnovers hindered progress in the Bedford case.

ROCKAWAY TOWNSHIP
MORRIS COUNTY, NEW JERSEY

SUMMARY

During their own testing in November 1979, Rockaway Township health officials discovered trichloroethylene in the municipal water system. The contamination was traced to one well, which was eventually pumped through aeration to waste to keep the TCE from spreading to other nearby wells. When other organics, namely diisopropyl ether and methyl tertiary butyl ether showed up in the course of increased monitoring at the two remaining wells, a water emergency was declared. Township officials then obtained an emergency appropriation to have carbon adsorption units installed. The adsorption units removed most of the organics, but the granular activated carbon (GAC) had to be replaced almost monthly, rather than every six to nine months as originally estimated. Rockaway Township, therefore, designed and installed a packed column air stripping unit that removes over ninety percent of the problem organics.

BACKGROUND

Rockaway Township is located along Interstate Route 80 in Morris County in North Central North Jersey. The Township has a population of about 20,000 people, most of which is supplied potable water from municipal water supply systems. Approximately half of the Township population is served by a groundwater supply system owned and operated by the Township. The remainder of the population is served by water suppliers in adjoining municipalities or by individual wells. A ban on new septic systems has effectively halted new construction in the Township.

Rockaway's ground-water supply system consists of three wells, located about 80 feet from each other as shown in Figure 1. The individual capacities of the three wells are:

Well No. 4:	350 gpm
Well No. 6:	550 gpm
Well No. 7:	1,000 gpm

When the wells are pumping simultaneously, the combined capacity of the system is about 2.0 mgd because of head constraints. Each well is approximately 100 to 200 feet deep and taps an unconsolidated, glacial deposit. Historically, the Township's ground-water supply has exhibited very good quality and required only disinfection prior to pumping into the distribution system.

DETECTION OF THE CONTAMINATION PROBLEM

In November 1979, trichloroethylene (TCE) was detected in Well Nos. 4 and 6. Township officials initiated the testing because of articles they had read in professional journals warning of growing problems with synthetic organics in ground-water supplies. The Health Department consequently sampled the finished water and sent the samples to their contracting laboratory for a standard VOC scan. Follow-up samples sent to the EPA labs at Edison, New Jersey confirmed that both wells had consistently high levels of TCE: 50 to 100 ug/l in Well No. 4 and 170 to 220 ug/l in Well No. 6. Both wells are located at the east end of the well field, nearest to the suspected source of contamination, which is about 1,600 feet east of the wells as shown on Figure 1.

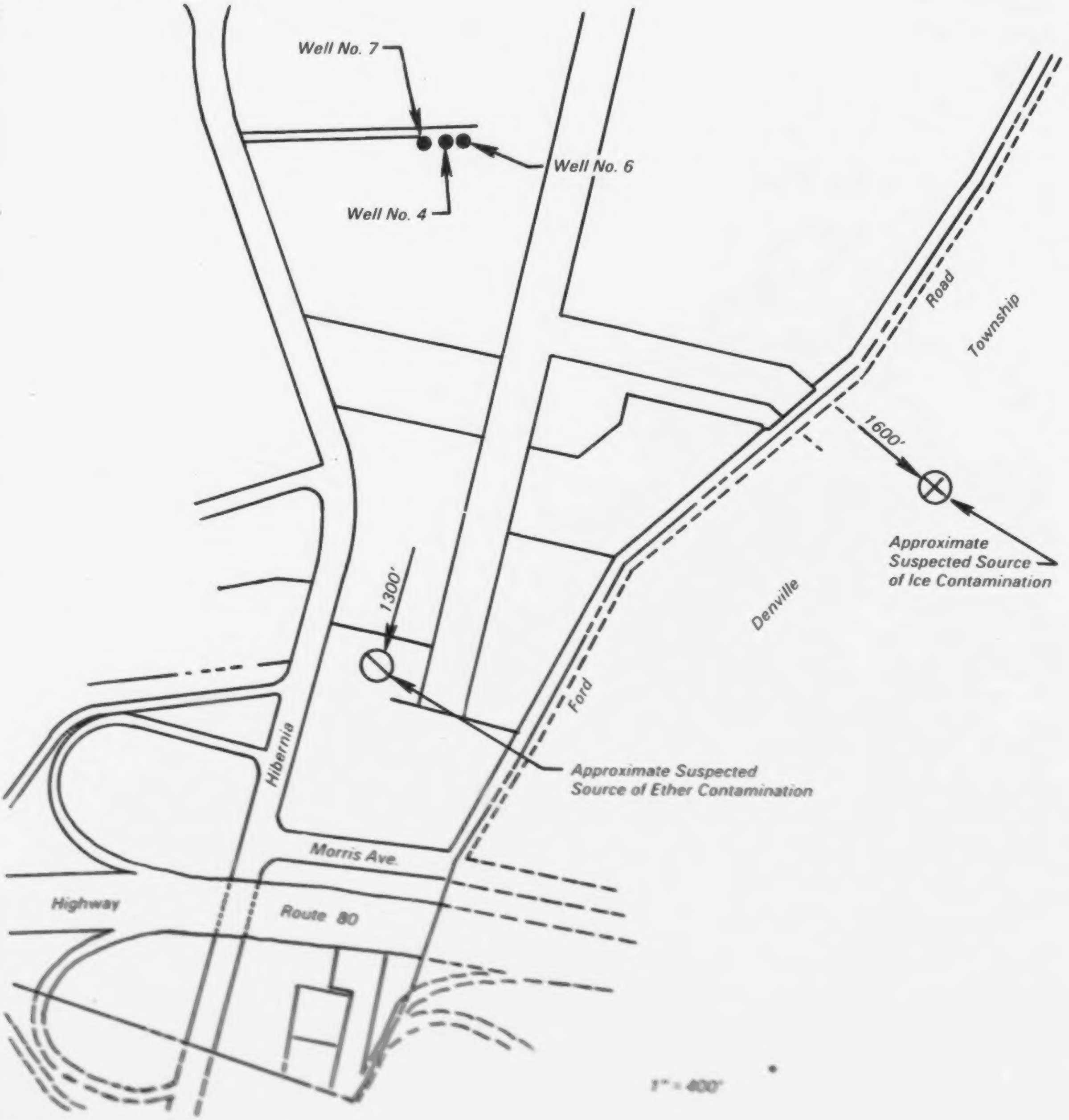
Well No. 7
Well No. 6
Well No. 4
Road
Township
1600'
Approximate Suspected Source of Ice Contamination
Denville
1300'
Ford
Approximate Suspected Source of Ether Contamination
Hibernia
Morris Ave.
Highway
Route 80
1" = 400'

Figure 1. Location of Rockaway Wells.

The New Jersey State Department of Environmental Protection (NJDEP) has set "action levels" at 50 ppb for a single VOC and 100 ppb for total VOCs. The New Jersey action levels are the same as those for New York. New York has probably spent more time and money on investigating the effects of organics in drinking water than any other state.

Below the action levels, no action is required on the part of the water system. Above these levels, the system is required only to notify the NJDEP. If VOC concentrations exceed the action levels, NJDEP will recommend whether the water supply should be taken out of service, taking into consideration the size and importance of the potential disruption in relation to the remainder of a municipality's water supply.

ACTIONS TO PROTECT WATER QUALITY

Since TCE levels in Wells Nos. 4 and 6 were considerably higher than the state's maximum recommended levels, township officials quickly took the two wells out of service. The Health Department then began looking for the source of contamination and researching the possible health effects of trichloroethylene. At the same time, officials started inquiries into treatment methods for removing the TCE.

EPA Region II was catacted for assistance, but was not able to offer much help. Region II did evatually tell Township officials that the Rockaway contamination problem would be put on the Superfund "Priority List" and therefore be eligible for financil assistance, but this information was incorrect. The Township also contacted EPA Region III officials who did provide an explanation of applicable regustions and guidelines and useful information on trichloroethylene in drinkin water.

By early 1980, the Health Department had investigated testing laboratories and had selected one of the less expensive labs to test the samples still being collected. Continuing tests soon showed that contamination was spreading to the remaining good well. To keep TCE levels low in Well No. 7, Well No. 6 was pumped to waste in an adjacent brook, preventing the contaminant plume from migrating westward.

By the summer of 1980, water usage restrictions were in place and the Health Department was engaged in discussions with the suspected industrial source, a company that used TCE. The source initially suspected was identified by the Health Department as about the only company in the Township that used TCE. The plant site also was upgradient from the Township well field. In cooperation with NJDEP, the Township convinced the suspect company to drill five test wells, one of which was on the far side of the plant site from the wells. This particular well showed the greatest levels of TCE, in effect exonerating the company as the main source and leading the search beyond the political border of Rockaway Township to another industrial site.

The site currently suspected is a federal facility built in the 1940s. The federal facility is a factory which reached full production in the 1950s and 1960s and used TCE baths to clean parts used in fabricating rocket engines. Since Rockaway Township has no jurisdiction outside its political boundaries, the matter has been turned over to the state for investigation and enforcement. Investigations into the source of TCE extended through the summer of 1980.

During this time the Township began to consider alternatives for dealing with the TCE contamination problem. Three main alternatives were suggested:

- drilling a new well in the western portion of the Township;

- purchasing water from the neighboring municipality of Dover; or
- treating the contaminated wells.

The first option would have required several years to investigate potential well sites and install a new well with sufficient capacity and quality. The second option would have required a contract, possibly a long-term commitment, to purchase water at a higher price than the Township could supply from their wells. Interconnecting pipelines and meters would also have had to be constructed to implement this option. The treatment options considered included both aeration and GAC adsorption.

As these alternatives were being considered, the Township began to receive taste and odor complaints about its drinking water. In October 1980, the TCE problem was compounded by the discovery of diisopropyl ether (DIPE) and methyl tertiary butyl ether (MTBE) in Well No. 7 at concentrations of 70 to 100 ug/l and 25 to 40 ug/l, respectively. The taste and odor threshold concentrations for these compounds are between 5 and 15 ug/l, explaining the numerous complaints from water customers.

The TCE problem became less important as the Health Department scrambled to deal with the new crisis. At first, the Township had no idea where the ethers were coming from. A Shell Oil Company gas station 1,500 feet upgradient soon became a prime suspect for two reasons. When Health Department officials noticed a drilling rig onsite, they went to the station to ask why Shell was drilling. While there, they spoke with police officers who mentioned that they had staked cut the station for several months to apprehend the culprit Shell suspected of stealing 50 gallons of gasoline nightly. After at least 6,000 gallons were lost, Shell began to suspect that a leaking tank was the culprit. Shell notified the New Jersey Department of Environmental

Protection (NJDEP) Spill Control group and began investigative drilling. NJDEP reportedly failed to notify the Township or the Bureau of Potable Waters' Groundwater Resource section.

The Township also had reason to suspect the gas station as the source of the ethers due to some detective work at EPA headquarters. When the Health Department, baffled by the appearance of more organic contaminants, called the head of the Criteria and Standards Division in the Office of Drinking Water Supply (ODWS), he had his staff perform a literature search on the two ethers. This effort turned up the fact that the methyl tertiary butyl ether was a proprietary gasoline additive used only by Shell. Throughout their efforts to resolve the various contamination problems, Township officials have stated that ODWS was extremely responsive.

Shell drilled about fifteen monitoring wells to determine the extent of aquifer contamination. Faced with their own information and evidence gathered by the NJDEP Groundwater Monitoring and Enforcement group, Shell agreed to pay for the hydrogeological work.

Meanwhile, although little health information on the new contaminants was available, the Mayor declared a water emergency when the ethers were discovered and went immediately to the Township Council with the engineering and health staff for an emergency appropriation of funds to install a treatment system. At that time residents were advised not to drink the water and were instructed where to obtain water for drinking. The Township was very prompt and open in notifying the public. Health Department staff spent the weekend following the announcement at a phone bank, answering more than 1,000 calls per day for several days.

The Township had already discussed GAC adsorption with the Calgon Corporation. When the water emergency was declared, officials had little choice but to choose a GAC adsorption system as the optimum treatment method for a range of organics and as the most expedient solution to the problem. After some negotiations with Calgon, the Township was able to purchase (rather than make the usual leasing arrangement) a GAC system on very advantageous terms. Within three weeks, two 20,000 lb. GAC contactor tanks were installed and the system was put on line. The system cost was estimated at $200,000.

Based on the TCE levels initially detected in the wells, the carbon was expected to last six to eight months before regeneration was necessary. After three months of operation, however, the DIPE concentration in the contactor effluent was 14 ug/l, MTBE was at 23 ug/l, and TCE was not detected. With the ethers "saturating" the carbon and breaking through earlier than expected, it became necessary for the township to replace the carbon every two months, rather than every six or nine months. By the end of 1981, the carbon was being replaced at a rate of about once every four to six weeks, at a cost of $32,000 per change. The Township negotiated with Shell to pay for the carbon.

Because of the replacement expenses due to the quick breakthrough of the ether compounds, the Township began to investigate aeration techniques as pretreatment to the GAC adsorption system. Officials at ODWS suggested they contact the EPA Cincinnati Municipal Environmental Research Laboratory (MERL) for help in conducting pilot studies. Pilot-scale tests were conducted at the well site using a packed-column aeration process, and test results indicated that adequate removal of organics could be achieved using aeration. Shell sent an engineer to help design a treatment installation and agreed to pay for an aeration facility. Consequently, a packed column was fabricated on site and put on line in December 1981 at a reported cost of $375,000 for the 1.7 mgd tower.

CURRENT STATUS

Currently, both aeration and GAC adsorption are used for VOC removal. As expected, the life of the carbon has been prolonged by reducing the influent ether levels to the GAC contactors. Removal efficiencies for DIPE have usually been greater than 99 percent, while about 95 percent of the MTBE and virtually all of the TCE are removed. At the time of this report (November 1982) the carbon on line when the aeration system was installed is still in place. The raw water still is pumped through the packed column to the contactor tanks and then to the distribution system, but Township and Shell officials feel the adsorption step is unnecessary at this point and are considering taking the tanks off line. The Township will maintain the capacity to bring carbon adsorption back on-line quickly in anticipation of the arrival of the major part of the ether plume.

The cost of service to water customers has increased from $0.27/thousand gallons to $0.48/thousand gallons with the addition of GAC treatment and aeration. This figure is estimated to drop to $0.40/thousand gallons after the well pumps are restaged.

INSTITUTIONAL INVOLVEMENT

The Township Engineer and Rockaway Township Health Department organized and carried out a response to the contamination problems with the help of several other agencies. The Township, however, took the lead in dealing with trichloroethylene and ethers in their drinking water. For a relatively small body with no previous experience with similar problems, the Health Department and others played an extremely active role in researching the situation and evaluating alternative solutions. Although officials felt they were often in over their heads and had to operate continually in "crisis mode," their responses were rapid, and little effort was spared to protect public health.

Briefly, the roles taken by other agencies in the Rockaway Township ground water contamination case were as follows:

- **U.S. Environmental Protection Agency (EPA).** At least four groups in EPA were involved in the Rockaway Township case. Region II and Region III were both contacted for assistance, but Region III was more helpful, even though New Jersey is located in Region II. The experiences of other regions indicate that this might simply have been the result of contacting the wrong person at Region II, or that Region III has had more experience in dealing with this type of problem since state programs in Region III are not as established as those of, for example, New York.

  The Office of Drinking Water Supply in Washington, and particularly Dr. Cotruvo, was credited with being very helpful in providing information on the contaminants detected in the Township's water. Similarly, researchers at the Municipal Environmental Research Laboratory were quick to provide technical assistance in evaluating and testing various organics removal techniques.

- **New Jersey Department of Environmental Protection (NJDEP).** Three sections of DEP had some involvement in the Rockaway Township case. Most helpful was the Groundwater Monitoring and Enforcement group, who came out and helped trace the gasoline spill. This group's work established the evidence used to prove that Shell was unquestionably the source of ethers in Rockaway water. The State's Bureau of Potable Water followed the Rockaway Township incident, but did not actually become involved except to verify one set of test results. The Spill Control group at NJDEP apparently made a major blunder in not notifying the Township or state ground water group of the Shell gasoline leak.

- **New Jersey State Health Department.** Rockaway Township officials stated that the state toxicologist was very helpful in supplying and interpreting health information. The toxicologist's quick response was appreciated since the Township was under fire to explain the health hazards associated with TCE and the others to the public.

HEALTH GUIDELINES

The health guidelines for drinking water quality recommended by the State of New Jersey (a maximum of 50 ppb of any one organic or 100 ppb of total organics) have already been outlined. The guidelines parallel those drawn up by the New York State Department of Health. Some other municipalities in New Jersey have reportedly been given different recommended maximum contaminant levels, however, so the health guidelines do not appear to be firmly established.

CONCLUSIONS

Rockaway Township officials eventually handled their organics contamination problem very well. With a minimum of outside assistance, the Township removed the immediate health hazard, tracked down the sources of contamination, designed and installed two treatment systems, and negotiated an agreement for one responsible party to pay for treatment. Health Department officials believe that the state and federal agencies should act only as technical and scientific resources whenever the local government has enough resources to take the lead.

In agreement with this view point, the local officials feel that their biggest weakness in dealing with the organics contamination was a lack of information on health effects. They call for some useful, consistent numbers to guide them in protecting public health. Township officials believe that testing and reporting requirements would turn up quite a few local water systems with organics levels in the 25-0 ppb range, as well as some wells with over 50 ppb which have not been tested thus far because of the desire to avoid the potential long-term costs of having to treat contaminated water.

SOUTH BRUNSWICK TOWNSHIP
MIDDLESEX COUNTY, NEW JERSEY

SUMMARY

The accidental discovery of trichloroethane in a South Brunswick Township water well in 1977 began one of the first cases of organics contamination in New Jersey public water supplies. South Brunswick Township Well No. 11, which supplied one-third of the Water Department's capacity, was closed when tests showed 400 to 500 ppb of trichloroethane (TCA).

The Township responded by hiring a ground-water consulting firm to trace the source of contamination. Geraghty & Miller drilled a series of monitoring wells that traced the contaminant plume towards an IBM plant. When notified, IBM voluntarily drilled their own wells, installed an air-stripping tower, and began pumping out the contaminated water. After two summers of dangerously low water supplies, South Brunswick eventually installed a new well to restore capacity. The Township also began pumping Well No. 11 to the sewer system and cut back on nearby pumpage to prevent further migration of the plume. IBM has reimbursed the Township $1 million for expenses incurred.

BACKGROUND

South Brunswick Township is located in Middlesex County, New Jersey, at the south end of the New York-Newark-Elizabeth sprawl. When the contamination incident was discovered, the Township Water Department was supplying water to about 18,000 persons with three wells. The Township wells are screened from about 80 to 100 feet and tap the lower, but not completely confined, aquifer. Average demands are about 2.5 MGD, with summer peaks near 4.25 MGD. Several heavy manufacturing and chemical industries are located in the Township.

DISCOVERY OF THE CONTAMINATION PROBLEM

In September of 1977, the New Jersey Department of Environmental Protection (NJDEP) tested South Brunswick's water as part of a state-wide program. No organics were detected at that time. In December, a local company that had found trichloroethylene (TCE) in chlorine gas cylinders it used warned other chlorine users to check their supplies. When the South Brunswick water was sampled, the analysis confirmed that both finished and raw water had TCE. Since this result was highly curious, another analysis was run that showed that the organic detected was actually 400 ppb of trichloroethane (TCA), not TCE, and that the chlorine feeder had nothing to do with the newly detected chemicals. Levels of tetrachloroethylene near 150 ppb were found later.

ACTIONS TO PROTECT WATER QUALITY

The first step taken by the Township was to close the contaminated well. Four hundred parts per billion of trichloroethane was not a borderline case in terms of health guidelines, so officials acted quickly to remove Well No. 11 from service. A new well at the other end of the township was not completed until two years later, so South Brunswick experienced several water crises during the summers. One of the two remaining wells also went out of service periodically for repairs, further complicating matters. Fortunately, the Township has 3.3 million gallons of storage (more than a peak day's demand) which helped a great deal during the shortage.

The second step taken by the Township was to hire a ground-water consultant, Geraghty & Miller. Geraghty & Miller performed a two-phase investigation, including studying potential sources, sampling existing wells, and drilling monitoring wells. The final report indicated that the TCA plume extended from an IBM facility seven-tenths of a mile to South Brunswick Well No. 11.

On the basis of this information, the Township went to IBM and negotiated a plan of action. IBM did more work to define the plume and drilled seven production wells off-site to pump out the contaminated water. The point source on IBM property was found to be a leaking buried tank. Geraghty & Miller estimated 500 to 1000 gallons of TCA had leaked. About 1 MGD of contaminated ground water is now being drawn out of the aquifer and pumped through an air-stripping tower. The treated water is discharged to a ditch or sprayed on a field to recharge the aquifer. Plans for injection wells are under consideration to recharge the aquifer and create a mounding effect which should halt the spread of contaminated ground water toward South Brunswick wells.

One year after the problem was discovered, monitoring wells indicated that the plume was migrating toward the remaining two South Brunswick wells. Well No. 11 was reactivated and pumped to the sewage system to halt the spread. When the new well came on line a year later, the Township switched one of the original wells to back-up capacity to reduce withdrawals near the contaminated zone. Well No. 11 is being pumped to waste at 0.85 MGD, which is upsetting local officials who are sensitive to the fact that their aquifer is threatened not only by organics and salt water intrusion but also by oversubscription.

CURRENT STATUS

For the short term, at least, the South Brunswick Township Water Department is in a relatively comfortable position. With the new well, they have ample capacity even if a third of their supply is lost. Moreover, as a result of various ground-water investigations, there are now almost 300 monitoring wells in the Township, about one per acre. This measure of security and the "early-warning" wells drilled by IBM around the South Brunswick production wells have taken the pressure off the Township. IBM has also followed through on their "good-neighbor" policy and reimbursed South Brunswick for roughly $1 million.

Besides the multi-million dollar five-year abatement program at the South Brunswick facility, IBM put in monitoring wells at all their manufacturing facilities nationwide. Several other problem sites were discovered. IBM has a highly-trained crew assigned to work on contamination incidents, and a South Brunswick officials says that IBM now has the best analytical laboratory in the State of New Jersey.

Another industrial source was discovered during the ground-water investigations in South Brunswick. A contaminated plume from this source was heading for Well No. 12. The industry, Mideast Aluminum, put in their own monitoring wells and eventually began pumping out the contaminated water and running it through aeration. The plume has retreated and now is confined under the plant.

Although the immediate supply problems have been resolved, the long-term security of the South Brunswick water supply remains uncertain due to potential contamination from unknown sites, salt water intrusion, and over-subscription.

INSTITUTIONAL INVOLVEMENT

Five years ago, even in New Jersey, water authorities had not had much experience with organic chemicals in ground-water supplies. Since the discovery of the South Brunswick case, much knowledge has been gained about organic contamination of drinking water, but the first few cases were definitely learning experiences.

South Brunswick Township handled the situation well, especially in negotiating with IBM rather than threatening legal action. Township officials emphasized the fact that cooperative efforts were much more productive than antagonistic efforts. Fortunately, the Township was able to bear the financial burden until reimbursed by IBM.

IBM, in this case as in others, cooperated completely with efforts to solve the contamination problem, although they never actually admitted complicity in the contamination problem. Their nation-wide program to investigate groundwater contamination associated with their manufacturing operations is an example to other chemical users and producers.

The New Jersey Department of Environmental Protection (NJDEP) did not provide any financial assistance to South Brunswick, but did offer help with any litigation the Township should undertake. The state geologist was very helpful in advising on hydrogeologic investigations. The local Board of Health never really became involved.

EPA provided some technical assistance to the Township. Cincinnati laboratory personnel set up their portable pilot plant at the contaminated South Brunswick well. Several treatment technologies, including granular activated carbon and resin adsorption as well as aeration, were demonstrated.

HEALTH GUIDELINES

The New Jersey Department of Environmental Protection set a recommended maximum of 33 ppb for trichloroethane in South Brunswick drinking water. The source of this number remains a mystery, especially since neighboring Rocky Hill was told that 100 ppb was acceptable and since 50 ppb of any single organic was suggested to Rockaway Township. Standard State of New Jersey policy limits any single organic to 50 ppb and total organics to 100 ppb.

CONCLUSIONS

The cooperation between IBM and the township has led to a satisfactory solution to the problem of contaminated ground water. The threat to public health was removed soon after it was discovered, a new water source was located, and efforts continue to clean up the aquifer. The Township is content with the resolution of the problem and now has quite a few defenses to warn of future contamination incidents.

Township officials maintain that their biggest problem in the TCA case was with testing. For quite a while they could not find three labs to agree on the contents of the same sample. This situation has improved greatly since 1977.

GARDEN CITY PARK WATER DISTRICT, NEW YORK

SUMMARY

The Garden City Park Water District was notified by the Nassau County Health Department in late 1977 that tetrachloroethylene had been found in the water supply. One well was closed in November of that year when two successive tests showed contaminant levels of 76 and 84 ug/l. Since one-fourth of the water system was already restricted due to excessive levels of nitrates, the tetrachloroethylene problem became very serious when two more wells had to be closed in April and June of 1981. As short-term measures, the Water District purchased water from neighboring systems and imposed sprinkling restrictions. Conservation efforts and the addition of a new well allowed Garden City Park to operate through the summer of 1982 without purchasing water. Plans to blend water from different wells to allowable nitrate levels and to start a pilot plant for organic removal testing have been approved by the Health Department to restore short-term capacity, but long-term plans to meet water demands are uncertain.

BACKGROUND

The Garden City Park Water District serves a population of about 24,000 in a three mile square area located in the southwestern portion of the Town of North Hempstead, Nassau County, New York. Formerly a dairy-farming region, the service area is now largely residential, with some light industry and commercial establishments. The Water District is served by the Nassau County public sewer system.

At the time the organic problem was discovered, the Water District had nine wells scattered throughout the service area. A new well came on line in early 1982. All wells but Nos. 1 and 2 pump directly into the distribution system after chlorination and treatment with caustic soda. Well No. 6 also has polyphosphate added. Well No. 9 is equipped with a nitrate treatment plant consisting of an ion exchange resin bed which is continuously regenerated through a closed loop, using salt as the regenerate. Mechanical problems have kept the equipment out of service several times. Waste brine and rinse water are discharged to the county sewer system, a procedure approved by special permit. Because of high operating costs, this well is used only during peak periods.

Total well capacity was about 14.5 mgd before the organics problem was discovered, with over a third of that restricted due to nitrates. The Water District operates 2.5 million gallons of elevated storage to handle peak demands. Peak summer demands are near 6.4 mgd, with average winter demands only 2.2 mgd.

DISCOVERY OF THE CONTAMINATION PROBLEM

Between 1975 and 1977, the US EPA conducted surveys to characterize the organic chemical contamination of the nations' drinking water systems. Alerted by the preliminary reports on these surveys and the discovery of contaminated wells near the Grumman Aerospace Corporation facility in Bethpage, the New York State Department of Health organized a cooperative effort with Nassau County officials to sample and analyze water from community wells. Beginning in 1976, wells were tested for six synthetic organic chemicals: 1,1,2-trichloroethylene, trifluorotrichloroethane, tetrachloroethylene, chloroform, carbon tetrachloride, and 1,1,1-trichloroethane. By the end of April 1978, 372 community water system wells had been tested: tetrachloroethylene and 1,1,2-trichloroethylene were found in 15 percent and 13 percent, respectively, of those sampled.

Tetrachloroethylene was found in Garden City Park Water District's Well No. 5 in November 1977 during the initial testing program. State Health Department guidelines limit any single organic contaminant to 50 ug/l, and total contaminants to 100 ug/l. Concentrations of 76 and 84 ug/l were detected, so the Water District complied with Nassau County's request to remove the well from service. The Nassau County Health Department (NCHD) requires annual testing for the six compounds listed in the paragraph above and requires notification if the individual maximum contaminant levels (50 ug/l) are exceeded. Testing at Garden City Park in 1981 showed levels of tetrachloroethylene over 50 ug/l in well No. 4. After well No. 4 was taken out of service, levels of tetrachloroethylene in nearby well No. 6 climbed rapidly until that well also had to be closed. One set of tests was performed by the NCHD, and the other by the Water District's consultants, Holzmacher, McLendon, & Murrell, P.C. (H2M). After these wells were closed, the Water District was left with only 3,680 gpm of unrestricted capacity, only about three-quarters of the capacity necessary for a peak day, even at 100% operation.

ACTIONS TO PROTECT WATER QUALITY

The immediate action taken by the Water District to protect their customers from the health hazards of contaminated water was in all cases to close the wells classified as "restricted". The Nassau County Health Department has drawn up a comprehensive "Policy Statement on Use of Public Supply Wells Contaminated by Organic Chemicals" that explains testing, monitoring and reporting requirements and water quality guidelines. Details of this document are discussed in the Glen Cove case study.

The Water Districts' consulting engineers, H2M, have made several suggestions for improving both the short-term and long-term available supply. The short-term options proposed relate principally to blending well water of acceptable quality with well water which exceeds standards to deliver a product water to the distribution network that meets the applicable standards or guidelines. The County has approved the blending technique for reducing nitrate levels, and a project to blend wells 1 and 2 into the 1.5 million gallon tank at the well site is nearing completion. The County has restated its opposition to blending to reduce organic levels, taking the position that there is no "safe" level of a carcinogen in a water supply and proposing conservation measures and the purchase of water before organic-contaminated water is used for drinking. In 1981, the Water District purchased 142 million gallons from the neighboring Albertson Water District, one of six interconnected systems.

H2M has also suggested several long-term programs to remedy the curtailed supply of water, agreeing that expected growth in consumption as well as current demands must be met. The consultants approach the long term objectives in two ways: installing a new water supply, or treating water at an existing well(s). The Health Department has urged Garden City Park to "vigorously pursue selection of a site for a new well", but recognizes the lack of an ideal location for a new well. Any new wells would have to be drilled in the north end of the Water District to avoid the contamination problems apparent in wells in other locations. Tapping a different aquifer may provide a solution. The minimum short-term resolution to the water supply shortage was estimated by H2M to cost $355,000, with the full program to increase supply estimated at $1,530,000.

With nitrate levels apparently declining and organic levels increasing, H2M suggests that treatment methods should focus on organics removal. They mention that carbon adsorption, synthetic resin adsorption, and air stripping have been used to control tetrachloroethylene, and propose a countercurrent packed tower air stripper as the most cost-effective technology. The Health Department agreed with H2M that Garden City Park should set up a pilot plant at Well No. 6 to test removal efficiences and to develop design parameters for that well and another potential site. H2M has decided that they have enough technical information to design and install a packed tower air-stripping plant without setting up a pilot plant, and plan a 1200 gpm (1.7 mgd) installation at well No. 6.

The restored capacity from Well No. 6 should meet short-term needs but not long-term demands. The Water District has contracted with a private firm, Ecolotrol, to plan a pilot biological denitrification plant on Well No. 1 or 2. The Water District believes that enough of the organics might be removed by the plant to meet both the nitrate standard and the tetrachloroethylene guideline. If so, a 2.5 mgd biological denitrification plant may be installed to meet long-term water demands.

CURRENT STATUS

The County Health Department has recently begun drilling monitoring wells to identify the source(s) of the organics discovered in Garden City Park Water District wells five years ago. Several landfills are suspected, but none have been positively linked to the tetrachloroethylene in Water District wells.

Conservation measures will be in effect to reduce water demands until the air-stripping plant is installed. The plant is expected to be completed in late 1983. In the summer of 1983, work should begin on the biological denitrification pilot plant designed by Ecolotrol. In the meantime, Water District officals are still investigating the possibility of using wells with tetrachloroethylene levels slightly over the 50 ppb Health Department guideline.

INSTITUTIONAL INVOLVEMENT

The organizations involved in the Garden City Park organics contamination problem are the following:

- Garden City Park Water District
- Nassau County Department of Health
- New York State Department of Health
- New York State Department of Environmental Conservation
- U.S. EPA
- Holzmacher, McLendon and Murrell, P.C. (H2M)
- Ecolotrol

The Garden City Park Water District is directed by a Board of Commissioners and operated by the office of the Supertendent. The Water District relies on the County for health information and on a private consulting firm, H2M, for technical and planning expertise.

The Nassau County Department of Health administers the basic State programs in addition to programs initiated by the County. The Department of Health is a large organization with a relatively large staff assigned to drinking water problems. The County Health Department has its own laboratory and specialists to carry out programs that most other municipalities would have to relegate to state authorities. Since Nassau County was the location of New York State's first detected cases of organics contamination in ground water, the Department of Health has extensive experience in dealing with contamination problems.

The New York State Department of Health is the organization that carried out the first studies of organics in ground-water supplies on Long Island. The State Department of Health has been involved in the Garden City Park case only indirectly, through the County Department of Health. The State developed the Interim Guidelines that address organic contamination and has analyzed the available medical and technical information to assist the counties with questions on health effects and treatment alternatives. A summary of information, as well as the results of several organics surveys, is presented in an excellent comprehensive report entitled "Organic Chemicals and Drinking Water", revised in April 1981.

The Department of Environmental Conservation and EPA were not active in the Garden City park organics case. The Water District's consulting engineers, H2M, have played a major role in evaluating alternatives to secure a sufficient water supply and in planning treatment methods. Ecolotrol has been involved with the specialized planning for a biological denitrification pilot plant.

HEALTH GUIDELINES

The Nassau County Department of Health administers the state health guidelines and regulations affecting community and non-community water supplies. The New York State Department of Health Interim Guidelines for organic chemicals specify that the level of benzene or of vinyl chloride shall not exceed 5 ug/l and that the level of any other single synthetic organic chemical contaminant shall not exceed 50 ug/l. Ground-water source community systems are required to monitor eighteen organic constituents, including six halogenated organics: 1,1,2-trichloroethylene, trifluorotrichloroethane, tetrachloroethylene, chloroform, carbon tetrachloride, and 1,1,1-trichloroethane.

The Interim Guidelines were adopted by the State Department of Health on January 13, 1977 and modified on February 25, 1980 as a direct consequence of detecting these organic contaminants in ground water. Concerns raised over the hazards associated with long-term consumption of these potential carcinogens prompted the State to take action.

CONCLUSIONS

The Garden City Park case involved only a few government organizations, but still touched on many technical topics. Although the County is drilling several monitoring wells, no real progress has been made in conclusively identifying the source of contamination. Conservation measures, more so than water purchases, were credited with avoiding severe water shortages when wells were closed. Finally and perhaps most importantly, the consulting engineers hired by the Water District had enough confidence in their own expertise and information from other projects to proceed with installing a full-scale packed column air stripper to remove the tetrachloroethylene found in ground-water supplies.

CITY OF GLEN COVE
NASSAU COUNTY, NEW YORK

SUMMARY

The Nassau County Health Department (NCHD) tested the City of Glen Cove's water in the summer of 1977 for organic compounds. Their analysis indicated that four of Glen Cove's wells contained trichloroethylene (TCE) and tetrachloroethylene above New York State's maximum allowable limits of 50 ug/l for any one organic contaminant and a total allowable limit of 100 ug/l for all such compounds. The Health Department subsequently restricted the use of those wells.

The City, faced with the loss of half of its water supply, was forced to purchase water from neighboring systems as well as to implement conservation measures that summer. One of two wells being developed at the time the contamination was discovered was then put on line, allowing water demands to be met. To further augment their reduced supply, the City retained an engineering consulting firm to study the situation. The firm found that no existing treatment technology was capable of treating large volumes of water containing trichloroethylene and tetrachloroethylene and helped the City secure an EPA research grant to test several possible treatment methods with pilot studies at one well field. The first two phases of this study are complete, and the third phase is currently in progress.

BACKGROUND

The City of Glen Cove is located in northern Nassau County, New York on Long Island Sound. The City supplies water to a population of about 27,000 with an average demand of 4.14 mgd and a peak demand of 7.72 mgd in 1981.

When the organics problem was first noticed in 1977, the City was operating seven wells drawing from intervals between 160 and 300 feet deep. The only treatment applied to the raw water is chlorination, with polyphosphate and sodium hydroxide added as corrosion control agents. Glen Cove is mainly a residential area, with some light industry and commercial establishments in the center of town.

DISCOVERY OF THE CONTAMINATION PROBLEM

Organic chemical contamination of the ground water in Nassau County was first discovered in October 1975 at two Grumman Aerospace Corporation wells in Bethpage, thirteen miles from Glen Cove. This discovery by the State Health Department and the detection of VOCs in eleven adjacent public and industrial wells led to the establishment of an extensive program to sample all public wells.

Sampling for volatile halogenated organic chemicals began in late 1976 in southeastern Nassau County. At that time, samples from public wells were routinely tested for eight such compounds: trichloroethylene, tetrachloroethylene, trifluorotrichloroethane, 1,1,1-trichloroethane, chloroform, bromodichloromethane, carbon tetrachloride, and 1,1,2-trichloroethane. Limited testing for vinyl chloride, 1,2-dichloroethylene, methylene chloride, bromoform and the non-halogenated compounds benzene and toluene was also carried out. The samples collected were analyzed by the U.S. EPA, New York State Department of Health, Nassau County Department of Health, and various consultants' laboratories.

In early 1977, the State Health Department developed "interim guidelines" to assist the Department in evaluating data and controlling the use of public supply wells. The guidelines limited vinyl chloride to 5 ug/l (micrograms per liter), other organic chemicals to 50 ug/l, and the combined level of all organic chemicals to 100 ug/l. These guidelines were based on a toxicological study in progress by the National Academy of Science which relied primarily on extrapolation of animal data and were predicated on a lifetime human exposure (70 years) to drinking water (2 liters/day) which would cause one additional cancer death per year in 100,000 to one million persons.

The Nassau County Department of Health sampled the Glen Cove municipal wells in the summer of 1977. Four wells (Numbers 22, 1-S, 20, and 21) were placed in the "restricted" category and closed due to organic contamination, mainly by trichloroethylene (as high as 300 ug/l) and tetrachloroethylene (as high as 375 ug/l).

ACTIONS TO PROTECT WATER QUALITY

The decision to close the contaminated wells was the first action taken to protect public health. The Nassau County guidelines for organics in drinking water are very clear and detailed, so closing the wells was not an arbitrary decision.

Faced with the loss of about half of the municipal water supply capacity, Glen Cove also had to implement conservation measures and purchase water. The City entered into contracts with the Sea Cliff Water Division to supply 0.70 mgd and with the Locust Valley Water District for 0.25 mgd to meet the summer demand in 1977. Conservation measures were credited with significantly reducing demand and minimizing the shortage.

By the summer of 1978, two factors, the closing of a industrial customer with a water demand of 1 mgd and the opening of a new 2 mgd well, allowed even summer demands to be met, although another smaller well (No. 2-S) was closed in August 1978 due to measured tetrachloroethylene concentrations in consecutive samples of 73 and 84 ug/l.

Two efforts initiated in 1977 and 1978 were directed towards ensuring the long-term availability of safe drinking water. Beginning in 1977, the Nassau County Health Department began investigations into the source(s) of Glen Cove's organic contamination problem. One study was conducted to identify local industries that used the halogenated organic solvents. Another study surveyed residences and commercial establishments, such as dry cleaners, to update knowledge of organic chemical usage and disposal practices in the vicinity of the contaminated wells. The other main line of investigation concentrated on methods of treating the water, rather than on isolating the source. The City and their consulting engineers entered into discussions with U.S. EPA that resulted in a research grant to test several possible treatment methods at the Glen Cove site.

The first study to identify sources of contamination was carried out by NCHD in June to December 1977. Over one hundred inspections/surveys were made of commercial/industrial sites near the Carney Street and Seamens Road well fields. This study concluded that no waste disposal practices were found at that time which could account for the extent of contamination at the Carney Street or Seamans Road wells. The contamination problem was therefore attributed to past disposal practices, perhaps as recent as the early 1970s. The Health Department recommended exploring the feasibility of purging the contaminated ground water as well as changing water supply practices. The difficulties in testing for dichloromethane, a suspected contaminant, were noted.

The second study by the Nassau County Health Department was conducted to find the source of contamination of the Seamen Road wells. This study looked more closely at drycleaners and unsewered residences in the area, as well as several commercial buildings and a distant (2,000 feet from wells) landfill. The NCHD concluded that the one remaining drycleaner was a potential source and ordered several changes at the facility. The report also recommended connecting all unsewered residences and continuing the investigation with subsurface exploration techniques. Finally, the Health Department proposed a specific program of observation well construction and sampling. No hydrologic/geologic studies of this type have been carried out to date.

In an effort to treat the contaminated water, rather than to find the source, the City retained the consulting engineering firm of Nebolsine Kohlmann Ruggiero Engineers, P.C. (NKRE) to design a feasible and economical treatment system. Through consultation with the U.S. EPA's Drinking Water Research Division, Municipal Environmental Research Laboratory (MERL), Cincinnati, it was determined that no existing treatment technology was capable of treating large volumes of water containing these organic contaminants. After preliminary tests of the Carney Street wells, discussions and negotiations between the City, NKRE, and the U.S. EPA resulted in a research grant (later a cooperative agreement) funded by the U.S. EPA to test several possible treatment methods at the Glen Cove site.

Phase I of the pilot project, begun in March 1979, tested counter-current diffused aeration and adsorption using resins. Phase II of the project began at the conclusion of Phase I, after modifications to the pilot plant equipment (including changes in resin-testing column size, installation of activated carbon towers, adaptations for a larger steam supply, and installation of a packed aeration tower and a cooling tower for air stripping) were completed.

The data developed during the two phases of testing showed that the most efficient system to reduce organic contamination to low levels was one using aeration followed by adsorption on resin. This approach allows treatment by aeration to efficiently strip all contaminants, significantly lowering the well water contamination levels, and then polishes the water with resin, thereby reducing regeneration requirements and extending the length of service time for the resins. The pilot project has shown that the target contaminant level is an important consideration in interpreting the data or determining the cost of treatment, and the effluent quality mandated affects the design parameters, length of service time for adsorbents and the overall system costs. Phase III of the pilot project is in progress. The following table shows the estimated cost ranges for the three systems tested:

ESTIMATED COSTS FOR FULL-SCALE INSTALLATION
(Thousands of Dollars)

System	Capital Costs	Annual Operating Costs
Diffused Aeration	228-471	122-342 ($0.19-0.33/thousand gallons)
Packed Column Aeration	477-684	130-378 ($0.21-0.36/thousand gallons)
Resin	308-953	77-228 ($0.12-0.22/thousand gallons)

CURRENT STATUS

According to the Health Department, the Glen Cove site is no longer considered a "hotspot" in terms of organic contamination. Since new wells have come on line, the present capacity is sufficient to meet water demands, and little further action is planned. The City and NKRE are examining the possibility of getting a grant for a demonstration plant based on pilot project results, but the outcome of their efforts is uncertain. Glen Cove does not seem interested in following up on the problem, as long as immediate water demands can be met.

INSTITUTIONAL INVOLVEMENT

The Nassau County Health Department has been the lead agency in dealing with volatile organics in the Glen Cove water supply. The Health Department, mostly through the Bureau of Public Water Supply, initiated the organics testing program in 1977 that discovered the problems with Glen Cove's drinking water. NCHD is responsible for administering the New York State Health Department Guidelines for organics in drinking water. In that capacity, the department classified Glen Cove wells into "restricted," "reserve," and "unrestricted" categories, with specific suggestions to the City as to approved use of each category.

The Nassau County Health Department also planned and carried out two residential/industrial surveys in the Glen Cove area, in an inconclusive effort to find sources of contamination. With a complete laboratory facility capable of testing for volatile halogenated and non-halogenated compounds, the Department offers strong technical support to testing and monitoring programs. In addition to providing technical assistance, NCHD reviews proposed alternatives for alleviating water shortages due to organic contamination.

Since the County has had over a dozen water systems with serious organics problems, the large staff and years of experience that NCHD can apply to cases of drinking water contamination is a definite advantage. Several other organizations that have been involved to a lesser extent in the Glen Cove case:

- **U.S. Environmental Protection Agency (EPA).** The federal government has been involved only in two aspects of the Glen Cove contamination problem. EPA research into the health effects of various organics was used by the New York State Health Department to set the guidelines used by Nassau County to recommend that wells be closed. EPA is also involved in funding the pilot tests at Glen Cove to compare and establish design parameters for aeration, resin adsorption, and granular activated carbon adsorption treatment techniques.
- **New York State Health Department.** The State Health Department has been involved in the Glen Cove case only indirectly. The State, however, deserves mention for its studies of organics and drinking water. At present, the NYSHD guidelines on organics in drinking water are being reviewed. Recommendations on standards for organics, rather than the present guidelines, are expected to be proposed in late 1982.
- **New York Department of Environmental Conservation.** The Department of Environmental Conservation has responsibility in New York under the State Pollution Discharge Elimination System and Water Classification System to protect the water resources of the state, including ground water. DEC has conducted a statewide survey of organic chemical use, storage and disposal which has been used in Nassau County to identify potential sources of ground water contamination.
- **City of Glen Cove.** The City of Glen Cove has played a rather passive role in resolving the problem of organics in its drinking water supply. Officials stated that once new wells restored the City's capacity to meet immediate demands, it reportedly became someone else's responsibility to investigate the source and extent of contamination. Consequently, Glen Cove now has no major plans to investigate the problem. Their consulting engineers are concluding the pilot tests at a Glen Cove well site, but unless federal money becomes available, no further action is expected.

HEALTH GUIDELINES

The State of New York first announced guidelines for synthetic organic chemicals in public water supplies in January 1977. These guidelines specify that the level of benzene or vinyl chloride shall not exceed 5 ug/l, that the level of any other single synthetic organic chemical shall not exceed 50 ug/l, and the combined total for such contaminants shall not exceed 100 ug/l. The State Health Department has extensively researched methods of estimating risks from organic chemicals and has reviewed many strategies for managing synthetic organic contaminants in drinking water, but has kept the 50 ug/l guideline for single synthetic organics. By Health Department references, 50 ug/l corresponds to a wide range of risk levels, as shown in the following table for some common organics.

NAS PROJECTED LIFETIME CANCER RISKS FOR INDICATED DRINKING WATER CONCENTRATIONS

Compound	Concentrations Corresponding to Risk Levels		
	1×10^{-4}	1×10^{-5}	1×10^{-6}
Carbon Tetrachloride	450.0	45.0	4.5
Chloroform	29.0	2.9	0.29
Dibromoethane	48.0	4.8	0.48
Tetrachloroethylene	220.0	22.0	2.20
Trichloroethane	46.0	4.6	0.46
Trichloroethylene	460.0	46.0	4.6
Vinyl Chloride	110.0	11.0	1.10

(all concentrations in parts-per-billion)

Note that the risk levels for the "allowable" 50 ug/l of trichloroethane and the "allowable" 5 ug/l of vinyl chloride differ by one and a half orders of magnitude. Despite this apparent inconsistency, the State of New York has the most extensive program for dealing with origanic chemicals in drinking water of any state investigated in this survey. The Nassau County Policy Statement on Use of Public Supply Wells Contaminated by Organic Chemicals is one of the most comprehensive documents on the subject produced by county government.

CONCLUSIONS

The Glen Cove contamination case differs from most others examined in several respects. First, the presence of organics was detected and a response was made under a well-funded, well-organized County Health Department program. Second, no hydrogeological study was made to determine the source of contamination. This kept Glen Cove from finding a responsible (i.e., liable) party and from being certain of halting the source of contamination. Third, a pilot project has generated quite a bit of information on treatment technologies that can be extremely useful to Glen Cove or other water systems with similar problems. The value of this data should not be overlooked.

VESTAL
NEW YORK

SUMMARY

Random sampling of New York water supplies by the State Health Department discovered high levels of trichloroethane in a well operated by the Town of Vestal Water District No. 1. The state came back and sampled all of Vestal's wells and found another, in District No. 4, contaminated with trichloroethane and tetrachloroethylene. Both wells were shut down in the spring of 1980.

District No. 4 faced a water shortage that summer and installed a portable granular activated carbon unit on the contaminated well until a new well came on line. The State assisted in tracking down the suspected source of contamination, a chemical company less than 300 feet from the well. The Town of Vestal and the State are currently involved in litigation against the company.

Water District No. 1 experienced no major supply disruptions, but it was feared that the contamination would spread to the two remaining wells in the district. The well is now pumped to waste to prevent migration of the organics, and a private contractor is performing a study to pinpoint the source. EPA recently sent investigators to the site to evaluate the case for Superfund assistance.

BACKGROUND

The Town of Vestal is located in Broome County in south-central New York State. Vestal supplies water to 27,300 persons, including 11,000 at the State University at Binghampton. The water system is divided into nine Water Districts, supplied by a total of eight wells. The wells tap into a moderately vulnerable aquifer at about 140 feet. The deep bed of gravel below the soil level allows rapid percolation.

DISCOVERY OF THE CONTAMINATION PROBLEM

In 1978, through one of the national water supply sampling programs, EPA randomly selected a Vestal well, No. 1-1, for organics analysis. The samples were delivered to the Cincinnati lab where they set on a shelf, unrefrigerated, for a year or two. When the samples were tested, some organics were detected, but although the results were published, they were dismissed as inaccurate because of poor handling procedures. In the spring of 1980, the New York State Department of Environmental Conservation (DEC) sampled ground water at nearby Endicott and, on a fluke, collected a sample from a Vestal well.

The results of organics analysis on that sample from Well No. 1-1 showed over 1500 ppb of 1,1,1 trichloroethane. The state came back and resampled all Vestal wells. This confirmation round of testing confirmed the results in Well No. 1-1 and also revealed that Water District No. 4 well No. 2 had 300 ppb of 1,1,1 trichloroethane and tetrachloroethylene.

ACTIONS TO PROTECT WATER QUALITY

The first step taken to protect water quality was to close the contaminated wells. State Department of Health guidelines are quite specific in recommending that water with greater than 50 ppb of a single organic (except vinyl chloride, which has a 5 ppb limit) or 100 ppb of total organics should not be used for drinking.

The two wells were contaminated by different sources. Well No. 1-1 was pumped to waste in the Susquehanna River to prevent the spread of contamination to the other two wells in District 1, located about 1500 feet downgradient. Levels of contamination have dropped from 1700 ppb to about 200 ppb.

The Town hired a local consultant to trace the source of contamination in District 1. So far, a considerable amount of drilling and many flow tests have determined the general direction of plume travel, but no source has been definitely identified. Vestal requested assistance from DEC for further investigations. EPA contractors were recently sent to the site to evaluate the case for Superfund aid. The EPA team reportedly copied the existing documentation in Town files and did no on-site investigations. Vestal has spent over $100,000 investigating the source of contamination.

Closing Well No. 4-2 severely restricted water supplies in that district of the Vestal water system. The Town put a portable GAC unit on the well to help meet summer water demands. When a well aready under construction came on line, No. 4-2 was taken off GAC and pumped to the Susquehanna. Trichloroethane levels have dropped from 200 ppb down to 50 or 100 ppb.

The DEC came in to trace the source of contamination in Well No. 4-2, curiously enough with State Department of Transportation funding. An obvious source, a chemical company located 370 feet from the well, was soon identified. Apparently the company had obtained a permit from DEC to rinse chemical barrels on a gravel pad behind the building. The Town of Vestal and the New York Attorney General are currently involved in litigation against the company.

CURRENT STATUS

Investigations in Vestal District No. 1 are still continuing while the resolution of the problem in District No. 4 is somewhere in the court system.

The Town is running out of money to finance further investigations and must find either the responsible party or another funding source. Even if Vestal is approved for Superfund monies, the funding probably will not be available for a year or two.

INSTITUTIONAL INVOLVEMENT

The roles of the various agencies involved in the ground-water contamination cases at Vestal have already been outlined. The Town of Vestal has played an active role in finding alternate sources of drinking water and in tracing the sources of contamination. The current town engineer was hired just two months before the contamination was detected, but he and his staff responded well at the time and have gone ahead in making contingency plans in case the problem worsens. Extensive research and several national ground-water conferences have provided useful information for making decisions on treatment and other technical responses.

The New York State Departments of Health and Environmental Conservation assisted in testing well water and tracing the sources of organics. New York has a fairly well established state program for dealing with organic contamination, described in the Glen Cove case study.

EPA Region II has been involved indirectly. The regional office provided some health information to the town, through DEC, and the hazardous waste sites branch recently sent in a team of contractors to briefly investigate the case for Superfund consideration.

Several other organizations have been involved peripherally. Roy Martin Consultants and other local firms have assisted in placing the new wells and tracing the sources of contamination, especially in Well No. 1-1. Calgon and the American Water Works Associaion have provided information on treatment alternatives. The local media was involved in the case, but reportedly criticized the water officials rather than distributing the few known facts of the problem. The County Health Department also hindered the investigation by the Town of Vestal. Finally, a local citizen and student group organized to lobby for no allowable levels of contamination has generated some political pressure.

HEALTH GUIDELINES

The New York State guidelines recommending less than 50 mg/l of any single organic chemical and less than 100 mg/l for total organics are described in detail in the case study of Glen Cove. Although the New York program for organics in drinking water is one of the country's most established, questions as to what levels of various organics will be acceptable in even the near future complicate decision-making. Water officials do not seem to have much confidence in the permanence of these guidelines and hesitate to take actions based solely on the present numbers. For example, a treatment plant cannot be designed without performance specifications, and the fear of designing an installation and then having the applicable standard change is a very real problem.

CONCLUSIONS

After a slow start in detecting the trichloroethane and tetrachloroethylene problems in Vestal drinking water, due in part to handling delays at EPA's busy Cincinnati labs, the town acted decisively in removing the contaminated wells from service. Fortunately, a new well was already being developed that was capable of replacing the closed wells. Vestal and the Department of Environmental Conservation then proceeded with efforts to find the sources of organics. One source has been found and the Town is continuing its search for the other.

As in many other cases, the lack of understandable information on the health effects of the synthetic organics was a major problem in responding to the situation. Town officials felt that there were not enough regulations or standards as to what levels of contamination were "safe," "acceptable," or "allowed" in drinking water. Vestal could have contracted to have a treatment system installed, if necessary, but not with assurances that the system would both meet any applicable standards and protect public health as much as feasible. A related problem was in dealing with the media, which soon became a major source of irritation. The Town simply did not have the answers about the potential health hazards that the newspapers wanted, and the media saw this weakness as a cover-up.

Another problem is the cost of investigative efforts. Vestal has spent over $100,000 in one district and is already running out of funds to continue work. The possibility of Superfund monies becoming available would be helpful, but a lack of information surrounding EPA's evaluations and the delays expected before funds are actually committed have kept local officals cautious about depending on government aid.

NORTH PENNSYLVANIA WATER AUTHORITY
LANSDALE, PENNSYLVANIA

SUMMARY

In response to requests by water customers, the North Pennsylanvia Water Authority (NPWA) tested its wells in 1979 for organic chemicals. Of the system's 51 wells, seven were found to have trichloroethylene and one had tetrachloroethylene, or perchloroethylene (PCE). All eight wells were closed, effectively reducing the system's supply by about one-third.

The NPWA's short-term response was to purchase water from a neighboring water company and to increase pumpage from the remaining wells to make up for lost capacity. The Water Authority then worked with EPA Region III and the Pennsylvania Department of Environmental Resources (DER) to trace the source of contamination. This task proved to be difficult due to aquifer heterogeneities and the large number of potential sources soon discovered. Eventually, only one well was definitely tied to a single source of contamination. A number of local industries have contributed to finding and halting sources of contamination.

The NPWA began treating some well water with granular activated carbon adsorption in 1981. Other treatment technologies, including an in-well aeration project, are also being tested.

BACKGROUND

The North Pennsylvania Water Authority is the major water utility for eastern Montgomery County, located in southeastern Pennsylvania. NPWA is a non-profit utility, governed by an elected Board of Directors, serving seven townships and municipalities. The Authority has 51 wells capable of supplying

5.2 MGD, but usually only 30 to 35 wells are required to be in service. The production wells are scattered all over the service area. Some of the very old wells are in the shallow aquifer at about 120 feet, while the new wells, generally in the lower aquifer, are as deep as 300 feet.

DISCOVERY OF THE CONTAMINATION PROBLEM

When a very large trichloroethylene (TCE) spill in nearby Collegeville contaminated the local water supply, officials at the North Pennsylvania Water Authority became curious about the quality of their own water sources. In July 1979, the Authority tested the water and found levels of TCE from 1 to 400 ppb in seven wells. One other well showed significant levels of perchloroethylene. Other chlorinated hydrocarbons such as 1,1,1 trichloroethane and cis-1,2 dichloroethylene were also detected in smaller amounts. The contaminated wells were scattered at various locations around the service area.

ACTIONS TO PROTECT WATER QUALITY

The eight wells found to be contaminated were immediately closed down. The Water Authority referred to the NAS 1 in 10^6 increased cancer risk level of 4.5 ppb for TCE in taking this action, although the State of Pennsylvania does not yet have primacy under the Safe Drinking Water Act and had no official response levels for organics in water supplies. About one-third of the NPWA supply capacity was lost when the wells were closed, although the difference was quickly made up by purchasing water from the neighboring Keystone Water Company. Keystone gets its water from a surface source, and complaints about taste and odor problems as well as questions about the wisdom of exchanging

TCE risks for THM risks often associated with surface water supplies have caused NPWA officials to minimize use of Keystone water.

The Pennsylvania Department of Environmental Resources and EPA Region III became involved in tracing the sources of volatile organics and in evaluating treatment alternatives. NPWA, with DER and EPA assistance, has put quite a bit of effort into locating the sources of contamination. Although the old industrial area in the middle of Lansdale had several suspected sources, a newly developed area with more recent activity was picked first for pump tests and periodic sampling to isolate sources of organics. Deep industrial wells and more shallow monitoring wells were used to define the contaminant plumes. NPWA carried out investigations through the summer of 1982, and a group of industries with potential TCE problems, organized as the North Penn Water Resources Group, sponsored investigations in 1982. The Water Authority and EPA have stressed a positive approach to resolving the organics problem, rather than threatening the industries with legal action, and have received excellent cooperation from the industries.

Only one contaminated well was definitely linked to a single industrial source. Another well was found to be contaminated by six different sources. The multitude of sources and fractured rock geology made investigations difficult, especially in downtown Lansdale. Several clean-up actions were taken on industrial sites found to be contaminated by organics used as solvents or degreasers. One very heavily contaminated site was excavated and the dirt hauled away. At several sites, the contaminated soil was dug up and spread over the ground to volatize the synthetic organics present. Other industries improved chemical drum storage facilities, replaced leaking TCE tanks, or installed other measures to control organic discharges.

In the meantime, efforts were underway to treat the contaminated well water. Shortly after the wells were originally closed, several were put back on line and pumped to the wastewater treatment plant to prevent localized TCE plumes from spreading to clean wells. In November 1981, a 100 gpm granular activated carbon plant was installed at one well, at a cost of $70,000, to return a portion of that well's capacity to service. Officials from the EPA Municipal Environmental Research Lab in Cincinnati tested the effectiveness of their portable packed aeration tower on one well in 1982. The Water Authority and EPA have also entered into a cooperative agreement for $90,000 to test new in-well aeration techniques. This two-year project is in the preliminary stages of design, although laboratory facilities with a gas chromatograph have already been installed for organics analysis. Operating expenses for the lab are estimated at $70,000 per year. North Penn's total costs thus far have totalled over $500,000, and average water bills have increased by $0.50 per month.

CURRENT STATUS

Recently, some previously-closed wells have been put back on line to reduce the amount of water purchased from the Keystone Water Company. Although the 4.5 ppb risk level was originally discussed, DER is now speaking in terms of 75 ppb, the number used as the long-term Suggested No Adverse Response Level, as an acceptable level for TCE. NPWA has only put wells back on line with TCE levels less than 5 or 10 ppb.

INSTITUTIONAL INVOLVEMENT

The Water Authority, Department of Environmental Resources, and EPA worked together on most aspects of the contamination problem around Lansdale.

Although DER was inundated with requests for assistance with chemical contamination incidents in 1979, the Department still managed to respond to North Penn's contamination problem. Several EPA officials from the Region III office and the MERL center in Cincinnati provided assistance in several stages of tracing and controlling organics in the drinking water supply. Both EPA and the American Water Works Association provided research grants to test VOC removal techniques.

The North Penn Water Resources Group, the organization of industries formed to deal with the TCE problem, has been very cooperative in allowing and assisting investigations on and off plant sites. Most, if not all, of these firms have probably contributed to ground-water contamination in the area, but the group still deserves credit for facilitating investigations. The success of this positive effort is largely due to NPWA's decision to emphasize cleanup efforts rather than determination of culpability.

Several engineering and ground-water consulting firms have been involved in the North Penn case. Until the Water Authority equipped its own laboratory, a private lab was also used for organics analyses.

HEALTH GUIDELINES

As mentioned previously, the State of Pennsylvania has not been given primacy under the Safe Drinking Water Act and therefore has no program to deal with organic chemicals in drinking water supplies. For lack of better information, the Department of Environmental Regulation initially proposed the NAS 10^{-6} increased cancer risk level of 4.5 ppb for TCE. Now the DER is using the Suggested No Adverse Response Level (SNARL) of 75 ppb for chronic exposure to TCE.

CONCLUSIONS

Several aspects of the North Penn Water Authority case are fairly unusual. First of all, the utility was fortunate that lost production capacity could be made up easily, even if at considerable expense, considering the prevalence of contamination sites throughout the service area. Second, the lack of a state drinking water program eliminated one agency usually involved in ground-water cases. Finally, the degree of cooperation between the Water Authority and the group of local industries using TCE has rarely been observed elsewhere.

Several aspects of the North Penn case are common to many other cases. The public "outrage" and intense media coverage hindered careful, deliberate response to the problem. In retrospect, NPWA officials feel that the decision to install a GAC adsorption plant as small as 100 gpm may have been too hasty. The major shortcoming that kept the public upset and complicated planning was the lack of understandable, consistent information on the health effects of organics in drinking water.

Informing the public about the detection of potential carcinogens in their drinking water caused an "incredible amount of panic." With several sets of health numbers for TCE being tossed around, and no solid information that the public could relate to, confusion was rampant. Local officials needed one "official" number for acceptable levels of TCE both to calm the public and to use as a goal in designing water treatment methods. The Water Authority has made great efforts to keep the media informed of progress in the case, and the initial furor has largely ceased.

Local officials also mentioned a need for more technical information. Improved knowledge of the transport of chemicals through soil, rock, and the water table is needed to better predict leaching, subsurface travel, and retention of various organic compounds. More information on site cleanup procedures, such as the relative merits of landfill disposal, impermeable liners, forced leaching, soil aeration, etc. was requested.

Finally, in another health-related topic, the tradeoffs in abandoning a ground-water supply contaminated with low levels of TCE for a surface water source contaminated with trihalomethanes need to be evaluated. The lack of a consistent basis for making this type of comparison has long been a problem.

VERO BEACH
FLORIDA

SUMMARY

Trichloroethylene and related volatile organics were accidentally discovered in Vero Beach's drinking water when the water supply was tested for trihalomethanes in 1978. The City traced the contaminants back to one well near the airport. After the well was closed, an investigation around the airport area revealed that Piper Aircraft had a buried tank of TCE that was leaking.

Once the suspected source was identified, test holes were drilled around the tank that confirmed that very high levels of TCE were present. After discussions between the City, Piper, and Florida Department of Environmental Regulation (DER), a dewatering well was drilled to prevent the acquifer contamination from spreading to other wells. After a major delay, a NPDES permit was finally approved to discharge the water from this well to a canal.

Vero Beach never experienced a serious water shortage because of the closed well, but new wells have since been drilled to supplement the City's supply. Local officials feel that they and Piper could have handled the problem as well and much more rapidly without interference from the State and EPA.

BACKGROUND

The City of Vero Beach is located on the Atlantic coast of central Florida. The City supplies water to about 21,000 customers at a normal rate of 7 to 8 MGD. About twenty relatively shallow wells are used by the City. The combination of very sandy soil and a high water table make ground-water supplies very vulnerable to contamination from surface spills as well as intrusion by salt water if wells are pumped at high rates. Vero Beach treats its water with coarse filtration and a lime softening process before distribution.

DISCOVERY OF THE CONTAMINATION PROBLEM

In 1978, a researcher for the Harper-Branch Research Foundation tested Vero Beach's finished water for trihalomethanes. The results of that analysis showed that very low levels of total trihalomethanes were present, but that another halogenated organic, trichloroethylene, was present at a level of 68 ppb. The city backtracked through the water distribution system and found that one well, production well No. 15 located on Vero Beach Airport property, was the source of TCE in the drinking water system.

ACTIONS TO PROTECT WATER QUALITY

The concentration of TCE in the contaminated well was 900 ppb. Based on health information from Harper-Branch and the Water Department, Vero Beach decided to close down the well.

With the immediate threat to drinking water quality removed, the City began looking at potential sources of contamination on the airport grounds. Very quickly they learned that Piper Aircraft had a buried tank for TCE. Piper pressure-tested the tank and found a leak in a corroded below-ground pipe fitting. After Piper drained the tank to prevent any more of the solvent from leaking out, shallow (12-15 feet deep) well points were put down around the tank to determine the extent of contamination. High levels of TCE were found to be fairly widespread, indicating that the tank had been leaking for some time.

After discussions with Florida DER and the City's consulting engineers, Gee & Jenson, Piper drilled a 60 foot deep interceptor well near the tank site. Samples from that well had over 10,000 ppb of trichloroethylene. The City applied to the state for a NPDES permit to pump the well to waste in a nearby drainage canal to prevent the spread of contamination to other wells. The State approved of the pumping plan, but EPA refused the permit until a baseline study of the discharge area was completed, since the effects of TCE getting into the salt water environment were unknown. The study cost Vero Beach quite a bit and the delay allowed the contaminant to migrate further.

In February 1982, after more than a year's delay, the Florida Department of Environmental Regulation authorized emergency pumping of the Piper well, with some treatment, because the contamination had spread to other wells. Eventually a consent agreement was developed by EPA and DER, requiring an analysis of the results of the treatment process used before discharging the contaminated water, an evaluation of other treatment alternatives, establishment of a monitoring program, and a hydrological evaluation. The NPDES permit was finally approved with Piper Aircraft listed as the discharger.

Piper had put in water lines from the purge well to the canal and had Gee & Jensen design a treatment method. Gee and Jensen settled on an aeration technique through spray nozzles to remove the volatile TCE. In reviewing alternate treatment techniques, the following options and cost estimates were considered:

Treatment Technology	Estimated Cost
Air Stripping	
(a) upgrade spray discharge system	$ 9,500
(b) design aeration tower	$ 26,400-52,800
Synthetic Resin Adsorption	$ 62,000
Steam Stripping	$350,000
Solvent Extraction	$555,000
Activated Carbon Adsorption	$810,000

Levels of trichloroethylene in the Piper well were around 7000 to 8000 ppb in August 1981 and have declined to 400 ppb fourteen months later. The air stripping process currently in use has approximately a 70 percent removal efficiency. About 0.25 MGD is being pumped from Piper's purge well. TCE levels at the end of the discharge spillway were less than 3 ppb.

At the time that the organic contamination was discovered, Vero Beach was in the process of drilling two new production wells. While the City never experienced serious water supply disruptions, a total of eight wells have since been drilled to satisfy current demand as well as projections of future growth. There are some problems with drilling in the area in that isolated spots of contamination by various chemicals are occasionally encountered.

CURRENT STATUS

At present, levels of trichloroethylene in the abandoned Vero Beach production well are down to trace amounts. Apparently, the contaminant plume has moved past that well and the purge well is preventing the residual contamination at the tank site from migrating towards the production well. City wells are still being monitored for organics and Gee & Jensen are still sampling and testing water at several points from the purge well, through the spray nozzle discharge, and down the canal. Trichloroethylene levels a short distance down the canal from the discharge spillway are below the detectable limit.

INSTITUTIONAL INVOLVEMENT

The City of Vero Beach and Piper Aircraft, in a rare example of government/business cooperation, worked together to resolve the problem. Once it became clear that Piper was at fault, the company became very cooperative in cleaning up the spill. Technical assistance from the Harper-Branch Research Foundation, a private, non-profit organization, was instrumental in detecting the original problem and carrying out the response. Harper-Branch was generally in charge of testing and monitoring programs. The City's consulting engineers, Gee & Jensen, designed and tested the treatment method for discharged water. The State of Florida became involved only in approving a permit to discharge purged water to the drainage canal. The state DER tentatively approved the NPDES permit, but EPA Region IV officials became quite upset at the request and orginally would not allow a discharge of TCE greater than 0 ppb. The agreement finally worked out with DER allowed up to 1000 ppb of trichloroethylene to be present in canal water several hundred meters downstream from the discharge spillway.

HEALTH GUIDELINES

The Department of Environmental Regulation finally imposed a maximum allowable level for TCE in drinking water of 0.00 mg/l. In response to earlier requests from Vero Beach, the DER merely sent the City a copy of a Federal Register which discussed EPA's approach to setting health standards. Apparently, DER later adopted the policy of limiting public exposure to potential carcinogens as much as possible.

CONCLUSIONS

The case of organic contamination in ground water at Vero Beach is somewhat unusual in that the City and the organization that caused the contamination worked together to resolve the problem, without assistance from the state health and enviromental agencies or EPA. In fact, Vero Beach officials claim they could have resolved the problem equally as well and much more rapidly without the state and EPA becoming involved. Frequent and confusing personnel turnovers at the EPA Region IV office and the lack of knowledge about the effects of TCE in a saltwater environment were sources of irritation to local officials. Although individual contacts proved helpful, the slow pace of bureaucratic response was difficult for local officals, highly concerned with a potentially serious ground-water problem, to understand.

A major reason for the Region's slow response was the lack of information available on the environmental and health effects of trichloroethylene and the other organics present in the ground water. Region IV simply had not had much experience with this type of problem. The NPDES process also seems inadequate for emergency pumping to purge aquifers of contaminants. The dichotomy between justifying industrial discharges versus efforts to prevent the spread of potential carcinogens to public wells should be recognized.

The testing, monitoring, and treatment design aspects of the Vero Beach case were handled competently by a private research foundation and the City's consulting engineering firm. The state agencies involved, however, were not able to provide useful information to the City, partly due to their relative inexperience with the health effects and control methods associated with organic chemicals in ground-water supplies.

ELKHART WATER WORKS
ELKHART, INDIANA

SUMMARY

The Elkhart Water Works was one of a thousand community water supplies sampled by EPA in a nation-wide ground-water program concluded in 1982. In April 1981 Elkhart was told that 94 ppb of trichloroethylene had been found in the city's finished water. Followup well-by-well sampling resulted in several wells being closed, leaving Elkhart with insufficient capacity for a normal summer.

More well tests, samples from observation wells drilled by the Water Works for EPA, and a study by the Water Works' consulting engineers outlined the contaminant plume and suspected sources by the Spring of 1982. At present, two interceptor wells between the sources and the main well field are being pumped to waste to purge the aquifer and keep the contaminants from migrating into the well field's zone of influence. No significant change in contaminant levels has been observed, and Water Works officials are planning another study to conclusively identify the source so remedial actions can be taken.

BACKGROUND

The Elkhart Water Works is a public utility, managed by a board of trustees under the Indiana Public Service Commission, that supplies the majority of water consumed in Elkhart, Indiana. The Water Works has 12,600 accounts for approximately 36,000 people in this city of 41,000. The remainder of the population is served by private or subdivision wells.

Elkhart's water supply comes from three well fields. The North Main Street Well Field has 15 wells, each with an average depth of over 50 feet and rated at about 1 mgd each. The Bower Street Well Field on the west side of town has two wells 70 feet deep and one well 135 feet deep, with a total design capacity of 4.5 mgd. The newest supply, the South Well Field, was put into service in 1966. South Well Field has three wells, each 100 feet deep with a combined design capacity of 3 mgd. Several of Elkhart's wells have been placed on reserve, due to high iron levels or other problems. With all wells pumping, maximum capacity is near 20 mgd, three-quarters of which is from the North Main Street Well Field. Peak demands at North Main Street are in the range of 12 to 14 mgd, with off-season lows near 5 mgd. The Water Works operates a 6.5 million gallon storage system, with 2.5 million gallons of that total elevated.

The United States Geological Survey completed a three-year study of northwestern Elkhart County in 1981 to define the general flow and quality of water in the outwash system, to determine if a proposed well field near the Municipal Airport (northwest of the city) would draw leachate from an industrial landfill, and to define the areal extent of ground-water contamination at an east-side industrial park and landfill. The hydrologic portion of the study reported that the outwash aquifers underlying the region are mainly composed of sand and gravel and are separated by a thick silt and clay bed. The saturated thickness of these deposits averages 175 feet and ranges from 85 to 500 feet. Under most of Elkhart, the silt and clay bed confines the underlying aquifer. Average hydraulic conductivities of the sand, and the sand and gravel, are 80 and 400 feet per day, respectively. Regional ground-water flow is toward the St. Joseph River. The sand and gravel soil has been described as "highly vulnerable."

The USGS investigation discovered that ground-water quality had, as expected, been degraded in some areas near Elkhart by liquid and solid waste disposal practices. Volatile organic compounds have been detected in residential wells near an industrial area in east Elkhart. The landfill on the northwest side was closed because leachate penetrated the shallow aquifer, unconfined at that point.

DISCOVERY OF THE CONTAMINATION PROBLEM

Through preliminary reports of the USGS study described above, Elkhart officials had reason to suspect volatile organics might be present in drinking water. In April 1981 EPA Region V notified the Water Works that Elkhart was on the list of 1,000 community water systems due to be tested for organics. When test results came back in May, EPA informed Elkhart that the finished water from the North Main Street plant contained 94 ppb of trichloroethylene. More samples were then taken to confirm early tests. The results of these follow-up analyses showed 57 ppb in the finished water and 270 ppb in the most heavily contaminated well, Well E. As much as 880 ppb of trichloroethylene has been detected in observation holes and closed production wells since.

ACTION TO PROTECT WATER QUALITY

In Elkhart, as in most cities faced with organics in their drinking water supplies, the short-term action taken to protect water quality was to close contaminated wells. Here, however, confusion over the allowable levels of TCE made the decision to close wells less clear-cut. The Indiana State Board of Health (ISBH) thought that 75 ppb (EPA's Suggested No Adverse Response Level) was allowable while EPA wavered between 45 and 4.5 ppb (the National Academy of

Science estimated 1 in 10^6 and 1 in 10^7 increased cancer risk levels). When the contamination problem was discovered, the Water Works took a conservative approach and immediately closed down the wells that showed significant amounts of TCE. In May 1981 water from one well contained 270 ppb TCE, so the definition of 'significant' was not critical. Since then, wells with as low as 17 ppb TCE have been closed to keep the quality of the finished water as high as possible. Water from the North Main Street plant now contains less than 1.5 ppb, but officials are not certain that they could always meet an EPA standard of 4.5 ppb for trichloroethylene.

One month after trichloroethylene was discovered in water from the North Main Street plant, the Water Works, under the supervision of an EPA Region V hydrologist, drilled five 2-inch observation holes generally upgradient of the well field. These 30 feet deep holes were to determine the direction the contamination was coming from. Test results in early July showed high contamination levels (several hundred parts per billion of TCE) in observation wells east of the well field. The observation holes and production wells continued to be sampled every two weeks to provide data for planning further efforts.

After EPA's initial involvement, the Indiana State Board of Health took over as the nominal lead government agency. The ISBH continued sampling and organized several meetings with the agencies and suspected industrial sources involved.

In the spring of 1982, the water utility hired Canonie Environmental to determine the extent of the trichloroethylene contamination. Under Canonie's supervision, the Water Works drilled eighteen more observation wells. Most of the wells were east of the North Main Street plant, around the suspected industrial sources. The suspected sources, the Excel and DuraKool companies, both used TCE in plating operations. Canonie sampled all the wells installed up to that point in March and was able to outline the areal extent of the plume fairly conclusively, since the wells were relatively close together. Beginning in May 1982, all water samples were sent to a private lab, since the ISBH lab could not provide the rapid turnaround time required.

At the conclusion of their study, Canonie presented several alternatives to the Water Works Board. One alternative was to install a north-south slurry wall between the source and well field, a four hundred foot long barrier extending south to Christiana Creek. On the east side of the slurry wall, interceptor wells would be placed to draw out the contaminated water. A second alternative was to install interceptor wells on the western edge of the industrial sites, irrigate to leach out the organics, and pump the interceptors to waste in the creek.

The Board, in consultation with EPA, the State, and the companies, decided to put two interceptor wells on the western edge of the DuraKool property. When Elkhart went to install the wells, however, DuraKool would not let any drilling take place until the Water Works released DuraKool from any liability in the contamination case. Water Works officials balked at this request and placed the wells directly across North Main Street on the eastern edge of the North Main well field.

After protracted negotiations, the Water Works obtained a NPDES permit from the State to discharge water from the interceptor wells to Christiana Creek. The state allowed discharges containing up to 500 ppb of trichloroethylene on the condition that some progress towards reducing these levels be made within nine months. The utility began pumping to the Creek in August 1982, at a rate of about 4 mgd. Some field tests of simple air-stripping methods, such as discharging the contaminated water through perforated plastic pipe, have been shown to reduce TCE concentrations in the effluent by as much as 40 percent, but the outfall presently runs directly into the Creek. The concentration of TCE in the effluent has varied around 300 ppb.

The State Board of Health has strongly recommended that the source of contamination be located and removed. The ISBH told Elkhart that they should consider air stripper and granular activated carbon treatment methods, as well. Elkhart experimented with rudimentary air-stripping, as described above, and contacted Calgon for information on portable GAC units, should the need arise. The state itself has become involved in on-site inspections and soil sampling on Excel and DuraKool property.

CURRENT STATUS

The Elkhart Water Works is now assuming that some remedial action must be taken, since concentrations of TCE in the interceptor wells have not declined. One factor that may force action is the ISBH NPDES permit, which requires Elkhart to show in early 1983 that effluent levels in water pumped to Christiana Creek have declined. The Board of Health has warned as recently as October 1982 that it objectives in the Elkhart case are to:

1) determine the extent of the contamination problem;
2) determine the need for emergency remedial actions;
3) identify the responsible parties;
4) solicit proposals for permanently remedying the situation;
5) work out a plan with the parties involved to pay for remedial action; and
6) begin remedial actions as soon as possible.

The Water Works has asked Canonie Environmental to submit a proposal for more work to pinpoint the source(s) of contamination. At the same time, Elkhart is looking for more witnesses employed by the companies suspected of dumping the chemicals. The water utility has spent about $150,000 thus far on the problem and, in the absence of government funding, must find the source of contamination to shift liability and the costs of clean-up to that party. Comprehensive on-site clean-up efforts could easily cost several million dollars. In the meantime, Elkhart is spending $1,200-1,400 per month on electricity to pump the interceptor wells, and $1,500 per month on laboratory fees.

Despite local efforts, the water supply for Elkhart is still restricted. If the summer of 1983 is accompanied by normal water demands, the Water Works will be very hard-pressed to meet those demands. One option for increasing water supply is to accelerate existing plans for the new well field on the northwest side of the city, but officials are still uncertain whether demands could be met.

INSTITUTIONAL INVOLVEMENT

A number of parties were involved in different aspects of the Elkhart ground-water contamination case. The USGS was one of the first agenices to become involved, when their investigation of ground water in Elkhart County discovered two areas where waste disposal practices had contaminated ground water. A national EPA survey of community water systems then detected the organics in the North Main Street well field.

After EPA's initial involvement, the City Water works and the Indiana State Board of Health directed efforts to find the source and to prevent the further spread of contamination. The ISBH dealt with the suspected industries very firmly and has insisted the industries take major actions soon to resolve the problem. The Water Works capably managed the initial investigation and hired a ground-water consulting firm, Canonie Environmental, to trace the source and to present alternatives to the state for securing a safe water supply.

HEALTH GUIDELINES

The Indiana State Board of Health generally passes on EPA information without much interpretation. In the Elkhart case, the ISBH was initially recommending a maximum allowable level of 75 ppb for TCE (the level of the EPA SNARL for chronic exposure) but has reportedly been suggesting a limit of 45 ppb (the concentration at which the NAS estimates a 1 in 10^5 increased cancer risk). The confusion surrounding the meanings of these items and what is truly "safe" has complicated the decision-making process immensely.

CONCLUSIONS

The case of organic contamination at the North Main Street well field in Elkhart has been a troublesome one. Although the wells found to be contaminated were immediately closed, and finished water quality (averaging 1-2 ppb TCE) is now being very carefully monitored, several problems still exist. Ground-water investigations have not yet conclusively implicated the suspected industrial sources. One of the sources has closed down local operations and may be hard to prosecute. Success in pumping out the contaminated zone of the aquifer to waste has been slow and it appears it will take quite a while to reduce TCE levels in local ground water. The City's capacity to supply water remains drastically reduced and next summer could bring dangerously low water levels. On top of these problems, the Water Works is running out of money to continue investigations.

Water Works officials feel that they should not be responsible for paying for investigative and remedial actions and would like to see the state or federal government assist financially. Technical assistance requested on the case was for more health effects information, improved subsurface monitoring methods, and research on aquifer management technologies to direct the movement of the contaminant plume away from the remaining production wells.

CITY OF BATTLE CREEK
MICHIGAN

SUMMARY

In 1981 sampling of private wells near a Battle Creek landfill accidentally uncovered the presence of organic contaminants in the municipal water system. After the city notified the state of the problem, the Department of Natural Resources applied to EPA for assistance. While EPA conducted a preliminary investigation, the city pumped the two most heavily contaminated wells to waste. Eighteen of thirty municipal wells eventually had to be closed, in accordance with Michigan Department of Public Health recommendations that no organics-contaminated water be supplied to the public. The County Health Department found that over 80 private wells between the public wellfield and the suspected industrial sources were significantly contaminated by as many as seven volatile organic chemicals.

The wells pumping to waste were shut down recently when a USGS report showed that increased pumpage was drawing contaminated ground water toward the wellfield. Meanwhile the demand for municipal water has increased due to the discovery of various organics in several cereal manufacturers' wells (and the subsequent closures of the wells), which has heightened the severity of the water supply shortage. Efforts to supplement the water supply through treatment or alternate sources have been of secondary importance relative to locating the source(s) of contamination and establishing legal liability. The situation at Battle Creek remains one of the potentially most serious organics contamination cases in the Midwest.

BACKGROUND

The City of Battle Creek owns and operates one wellfield located in the northwest portion of the City. The Verona wellfield supplies water to the City of Battle Creek, an industrial park, and parts of four townships. The total population served is slightly over 50,000 persons. Several major breakfast cereal maufacturers also obtain their potable and production water from the city system. These manufacturers and other industries are located south of the wellfield, beginning several hundred yards down the valley. A railroad yard crosses northeast through the industrial complex to the wellfield. Between the wellfield and the industrial complex lies a residential section of 100 to 150 older homes. These residences obtain water from relatively shallow private wells.

The Verona wellfield, which borders on the Battle Creek River, has four production wells on the west side of the river and 30 on the east (see Figure BC1). Most of the municipal wells tap the Marshall sandstone formation at depths of 100 to 160 feet. Residential wells in the area generally tap the upper Marshall formation and the overlying glacial deposits, only 20 to 60 feet deep. Some of the municipal wells drawing from the Marshall formation are capable of yielding several thousand gallons per minute. Battle Creek had thirteen wells that could consistently yield 1,000 gpm each. These and other wells can be pumped at high rates without significant drawdown. Depending on seasonal demand, pumping from the Verona field ranges from 7,000 to 12,000 gpm. The annual average is about 9,000 gpm. Of this total, about 5,000 to 6,000 gpm is currently pumped to just two industries.

Ground water in the immediate area generally flows towards Battle Creek River, except at Verona wellfield where flow is towards the production wells being pumped. At peak summer periods (when withdrawals are as high as 12,000 gpm), water is drawn to the wellfield from several thousand feet away. During these periods, water is drawn to the wellfield from strata underlying the industrial sites. In winter, when withdrawals are normally 7,000 gpm, the zone of influence is smaller, and the east-west divide between water flowing to the wellfield and water under the industrial sites flowing to the river shifts northward, reducing the movement of water under the industrial sites to the wellfield.

DISCOVERY OF THE CONTAMINATION PROBLEM

In August 1981, the Calhoun County Health Department took water samples from residences with private wells in the northwest part of the city. The sampling was undertaken in response to complaints of taste and odor problems in wells near the Cereal City Landfill, several miles from the Verona wellfield. When the test results came back from the state labs, county officials notified one residence, a rectory, that volatile organic chemicals had been discovered in the well water and that the residence should consider hooking up to city water. The minister informed the county that his water was not from a well, but from the municipal system.

The health department took more samples to confirm the preliminary findings. When the results showed that low levels of organics were indeed present in municipal water, they notified the city of the problem. The city immediately began testing through the distribution system and at the Verona wells. These September 1981 tests showed that ten wells had some degree of organics contamination. Plant tap water contained 10 ppb of cis-1,2 dichloroethylene, 4 ppb of trichloroethylene, and smaller amounts of dichloroethane, perchloroethylene, and trichloroethane. Individual well samples showed levels as high as 12 ppb for dichloroethane, 91 ppb for trichloroethane, 66 ppb for dichloroethylene, 26 ppb for trichloroethylene, and 44 ppb for perchloroethylene.

ACTIONS TO PROTECT WATER QUALITY

The position of the State of Michigan Director of Public Health is that every effort should be made to limit the amounts of organics in drinking water. Consequently, the ten Battle Creek wells that showed any contamination (over 1 ppb, defined for these purposes as the detectable limit) were closed. The Director's position was formalized in a December 1981 letter that presented the state policy on organics and public health. In that letter, the director underscores the frustration of having to make such an important decision on the basis of incomplete information, and opts for the most conservative choice.

Besides closing the contaminated wells, other short-term responses to the discovery of organics in Battle Creek's water included continued weekly testing of city wells, initiation of a program by the county to sample nearby private wells, and notification of the public about the organics problem and associated health risks. Since levels of contamination appeared highest in wells on the southeastern edge of the wellfield, city and state officials assumed the contamination was moving from the southeast towards the northwest. To keep the contamination from spreading further into the wellfield, the two most heavily contaminated wells, Nos. 32 and 35, were pumped to waste in the river. Continued monitoring has led to eight more wells being closed, leaving only twelve wells (capable of 9,150 gpm, less than half of the city's previous production capacity) in service.

Simultaneous testing by the Calhoun County Health Department began turning up private wells south of the wellfield with organics contamination. The following table compares levels in public wells with levels in private wells for the seven organic chemicals detected. Since laboratory limitations (all organics tests for the city and county were run by the State Department of Public Health) allowed the county to test only a dozen or so wells at any one time, it took several months to find that a large number of wells were seriously contaminated. One year later, some wells still had not been tested.

MAXIMUM LEVELS OF ORGANIC CHEMICALS IN WELL WATER

Contaminant	Concentration in City Wells (30) (ppb)	Concentration in Private Wells (over 100) (ppb)
perchloroethylene	44	230
trichloroethylene	34	657
cis-1,2 dichloroethylene	79	3,900
1,1 dichloroethylene	5	38
1,1,1 trichloroethane	99	43
1,1 dichloroethane	12	149
1,2 dichloroethane	3	325

The County has developed three form letters to notify residents with contaminated wells; these explain that the well water should not be used for drinking, should not be used for cooking or drinking, or should not be used for bathing, cooking, or drinking, depending on the degree of contamination. In all cases, private well owners are now told where they can pick up city water for household use. One of the companies suspected of causing the groundwater problem has agreed to buy $5000 worth of bottled water for residents with contaminated wells.

In November 1981, the Michigan Department of Natural Resources (DNR) prepared an emergency action plan to obtain EPA assistance on the suspected contamination sites. The plan contained a site summary, site status, and emergency action plan. In late December EPA agreed to provide a response to the DNR plan.

The first phase of the EPA response was handled by a Technical Assistance Team (TAT) from EPA's contractor, Ecology & Environment, Inc. The TAT drilled 15 wells near the wellfield and both upgradient and downgradient from the suspected sources. Water and soil samples were collected and analyzed. The results of the TAT investigation indicated that three sites could have contributed to the organics problem in Battle Creek ground water; an industrial solvent reclamation facility that handled large quantities of the substances in question, a railroad yard and former maintenance facilities where degreasers were used, and a landfill located one mile south of the wellfield. The TAT study was limited to a $25,000 budget but was sufficient to place Battle Creek on the Superfund national priority list, allowing EPA to provide additional assistance.

By February 1982, the agencies involved in the Battle Creek case had been organized into a Task Force under the guidance of the state Department of Public Health (DPH) Regional Engineer's office. The following organizations are represented on the Task Force:

- Michigan Department of Public Health (DPH)
- Michigan Department of Natural Resources (DNR)
- U.S. Geological Survey (USGS)
- U.S. EPA, Region V, Office of Superfund
- Calhoun County Health Department
- City of Battle Creek
- Kellogg Company
- General Foods Corporation (Post)
- Ralston Purina Company
- Michigan Department of Commerce

The Task Force was set up to coordinate activities directed towards defining the source and extent of the problem and, subsequently, controlling the contamination problem.

The cereal companies are on the Task Force because of their concerns about using contaminated water in their manufacturing processes. Several of the cereal companies' wells showed low levels of organics. To keep their product as "wholesome" as possible, they switched over to city water in February 1982. The increased demand severely taxed the already reduced capacity of the Battle Creek system. In the previous year, the City had completed a new $4.5 million high capacity pumping station that was to provide enough capacity for an estimated 20 years of local growth. When Kellogg and General Foods switched to city water, they increased base demand by 4,000 to 5,000 gpm, roughly doubling the amount of water the City had to supply. The capacity deemed sufficient for 20 years of growth was used up in one month. Besides straining the City's water supply capacity, the increased pumpage drew more water from the contamination zone towards the wellfield.

In the summer, while the DNR and EPA were concluding site investigations, the City of Battle Creek contracted with USGS for some ground-water modeling studies of the six by six square mile area around the wellfield. The $32,000 study concluded that shifting pumpage patterns would not prevent migration of contaminants toward the Verona field. In fact, simulations showed that withdrawing 2,000 gpm at Well Nos. 32 and 35 near the south edge of the field was compounding rather than alleviating migration towards wells. Battle Creek, therefore, stopped pumping the wells to waste in August 1982.

The City also began designing an additional high service system to supply customers. The USGS report was relied upon to provide the background basin information required to place additional high-capacity city wells. In other efforts, the County represented the townships in negotiations with the Department of Commerce to secure funding to extend City water mains to the affected private homes.

In the fall of 1982, the City and a national ground-water consulting firm sponsored a conference in Battle Creek on volatile organic compounds in ground water. Over sixty state and local government and industry representatives attended. All reports indicated that the conference was highly successful in providing technical information and a basic education in ground-water contamination.

CURRENT STATUS

In October 1982, EPA Region V Superfund officials met with the three suspect companies to work out a plan of remedial action. By the end of November, EPA wanted the companies, singly or collectively, to agree to take responsibility for further efforts, to undertake a feasibility study, and to outline the scope of work for permanent remedial measures. The companies suspected of causing the organics contamination are not expected to comply willingly, since none have been proven guilty of contaminating Battle Creek's drinking water.

The Michigan DNR and EPA are handling negotiations with the suspect companies. The two agencies are also expected to begin evaluating treatment alternatives. The Michigan DPH is keeping a close watch on the situation and searching for more health information. Calhoun County is negotiating with the State Department of Commerce to extend water mains to the owners of contaminated private wells. The county Health Department is also still sampling previously untested private wells. The next steps in resolving the Battle Creek water crisis will depend on the outcome of additional hydrogeological investigations by the EPA Field Investigation Team and legal discussions.

INSTITUTIONAL INVOLVEMENT

The lead agency in the Battle Creek organics case has been the Michigan Department of Public Health. Officials in the DPH office of Water Supply direct the Task Force of local, county, and state government and industry representatives. Since the discovery of organics in drinking water supplies for Battle Creek and several other municipalities, DPH has initiated a statewide sampling program for public water systems. The laboratory in Lansing is the only DPH facility in the state capable of testing for halogenated and nonhalogenated organic compounds. Severe budget cutbacks in Michigan have forced all of the state's branch labs to close.

Several of the agencies in the Task Force have been more heavily involved in tracing the source of contamination and assuring a high quality drinking water product than others. The roles of the major agencies have been as follows:

- **Michigan Department of Natural Resources.** The DNR has been the primary state agency involved with site surveys, hydrogeological investigations, and industrial discussions to find the source of and clean up the assorted organics in ground water. DNR has a drilling rig and a hydro/geo staff capable of aquifer studies, but again, budget cutbacks have slowed responses to water quality problems.
- **U.S. Geological Survey** The study USGS performed for the City was quick and thorough. In the course of the study, the USGS determined ground water flow patterns and rates and made suggestions on pumpage patterns to minimize drawing contaminated water to the Verona wellfield. Several dozen observation wells drilled by USGS (in addition to wells drilled by the EPA TAT) are still available for sampling to monitor the position of the contamination plume over time.

- **U.S. EPA**
  EPA Region V has been a major participant in resolving the problem at Battle Creek, mainly through their Superfund Office. The Technical Assistant Team study, completed last spring, and the Field Investigation Team work, still in progress, are the two main efforts to determine the source(s) and extent of the organics in ground water. The Office of Superfund is also involved in negotiations with the suspected sources to set up and ascertain funding guarantees for remedial actions on the industrial sites and possibly at the City wellfield.

- **Calhoun County Health Department**
  The County Health Department has worked closely with DPH to sample private wells that might be contaminated by organic compounds. Since August 1981, the county has tested over 120 wells, mostly in the residential area south of the Verona wellfield. About two-thirds of the wells tested have proven to be contaminated with at least one of the compounds previously mentioned. The Health Department would like to do more sampling, but this effort is constrained by limited laboratory capacity at Michigan DPH.

- **City of Battle Creek**
  The City has been involved in most of the work done so far to find the source of and a solution for the contamination problem, and has worked especially closely with DPH. EPA and Michigan DNR have been working more closely with each other, rather than with the city, although the Task Force has been effective in bridging communications gaps between the agencies.

  Battle Creek has not had to spend a large amount of the Water Department budget on the organics problem, but the situation has been very time-consuming. Since the state lab has provided all the analytical work, the USGS project and small changes in the water system have been the only direct expenses incurred. Still, the organics problem is using enough resources to require rate increases in the near future, especially if the City has to pay for new wells or major system upgrading.

HEALTH GUIDELINES

As discussed earlier, Michigan has no "action levels," per se, for responding to organics in drinking water. Instead, the Department of Public Health considers each case individually and makes recommendations to limit human exposure to potential carcinogens as much as possible. In the case of Battle

Creek, every well that showed contamination by organics was closed, since some of the lost capacity could be made up by increasing pumpage from other wells. It is doubtful, however, that normal summer demands can be met by the existing number of wells. In other organics cases in Michigan, such as Petoskey, sole supplies have not been closed since alternative sources were not available.

Department of Public Health officials would welcome more information on the health risks associated with various organics in drinking water, but express hesitation at accepting a federal standard, preferring to have more discretion in protecting water quality.

CONCLUSIONS

The Task Force members are proceeding relatively smoothly towards resolving the problems of various organics in Battle Creek wells. Several strengths and weaknesses in response to the problem are noted below:

- Qualified, concerned assistance was available to the City from the State of Michigan.
- Some communication lapses between agencies hindered progress, but formation of the Task Force improved coordination.
- Severe State budget cutbacks have limited organics analysis capabilities. Private wells that may be severely contaminated still have not yet been tested.
- With seven VOCs present in Battle Creek wells and three sources suspected, investigative efforts have become very complicated.
- An educational conference on volatile organics in ground water was sponsored by a private ground-water consulting firm. Many local, state, and industry representatives attended and spoke very highly of the value of this type of meeting.
- Delays in Superfund investigative efforts have mildly frustrated local officals who need a solution to their problem soon.

CITY OF PETOSKEY
MICHIGAN

SUMMARY

During testing for trihalomethanes in the City of Petoskey's water supply, trichloroethylene and cis-1,2 dichloroethylene were found at concentrations of 45 ppb and 20 ppb, respectively. Since the city has only one well, located on the Lake Michigan shoreline, the source could not be closed down. The State Department of Public Health and Department of Natural Resources have been following the case closely since 1981 to isolate the source of contamination and locate a new water supply. At present, contaminant levels have declined somewhat but well drilling has not yet found a new supply capable of sustaining the pumping rate required.

BACKGROUND

The City of Petoskey is a small community located on the Lake Michigan shore in the Northwestern Lower Peninsula. The entire water supply for the City comes from one large infiltration well 50 feet from the Little Traverse Bay shoreline; a cone-shaped pit about 36 feet wide and 17 feet deep. The well is capable of providing 3,000 gpm (4.3 mgd) without noticeable drawdown. Average daily demands are about 1.4 mgd, with summer peaks (due to resort customers) near 2.1 mgd. The raw water is fairly soft and low in iron, as might be expected of lake water. Chlorination and fluoridation are the only treatments applied to the raw water before it is pumped into the distribution system.

One well has provided a sufficient supply of water for the 10,000 persons served in the City and parts of adjacent townships. For the past several years, however, the Michigan Department of Public Health (DPH) has been urging the city to install another well because of the vulnerability of the pit well in the City and because state policy recommends at least two sources of water to maintain a reliable supply. Petoskey has directed a ground-water consultant to begin looking for a suitable location for a new well.

DISCOVERY OF THE CONTAMINATION PROBLEM

On August 12, 1981 a water sample was collected from the Petoskey water system for trihalomethane (THM) analysis. The sample was collected by DPH in response to an inquiry by the local health department director. Although the finished water received chlorination, it had not been sampled previously because the source was technically defined as ground water and the water system was small enough to be excluded from EPA monitoring requirements.

As expected, the THM levels were low. The analysis performed by the state laboratory, however, showed the presence of two other organic compounds, trichloroethylene (TCE) at 12 ppb and dichloroethylene at 7 ppb. DPH notified the city manager and water superintendent of the sampling results and the significance of the organic compounds. Five more samples were collected at various points in the water system in early September. The table below shows the results of the analysis of those samples.

Compound	DPW Garage	City Hall	Lockwood Hospital	Plant Tap (New Pump)	Plant Tap (Old Pump)
cis-1,2 dichloroethylene	11	23	21	7	27
trichloroethylene	19	38	35	12	45
1,1 dichloroethylene	ND	ND	ND	ND	≥1

All samples showed the presence of some THMs, but total trihalomethanes were at levels of 18 ppb or less. The results of the plant tap sample from the old pump station were confirmed using mass spectroscopy. Selected samples were analyzed using a full VOC scan. No other organics showed up at significant levels, although low concentrations of phallates were noted. Continued testing over the past year has indicated that organics levels are declining slightly.

ACTIONS TO PROTECT WATER QUALITY

The normal response in Michigan to detection of organic contaminants in a public well is to close down the well. The State has no "action levels" set for organics, but suggests that the levels of organic chemicals in drinking water be limited as much as possible. In some cases, wells showing 1 ppb of TCE have been closed. At Petoskey, the city only has one well, and the presence of 20 ppb of TCE in the water system was deemed less hazardous to public health than closing down the City's entire water supply. No other water systems are close enough to Petoskey to make an intersystem connection feasible.

City officials met with their consulting engineers and the local health officer on September 16, 1982 to discuss a response to the problem. They decided it was necessary to inform the public of the presence of the organics in drinking water and issued a press release explaining what was known about the problem. Continued sampling was planned, including raw water samples and plant tap samples to ensure that contamination was not being introduced by the chlorine or fluorine feed systems. The City used an independent laboratory for their followup analyses.

Results of additional testing showed that levels of trichloroethylene and dichloroethylene were consistently twice as high in samples from the old pump station as from the new pump stations. The intakes for each station are only several feet apart in the well. The majority of pumpage has since been shifted to the new pump station to lower the amounts of organics sent to the distribution system.

At the September meeting, the City also authorized their engineers to proceed with developing specifications for a test well located 1/2 mile southwest of the City. The proposed site for the new water source had been reviewed and approved for test well drilling. A 2" hole drilled on that site hit an aquifer at 240 feet that appeared to have sufficient quantity. The severe winter slowed drilling operations, so it was not until March 1982 that a 6" test well was completed. Test pumping showed that nitrates were consistently present. The results of several analyses indicated that 6 to 7 mg/l of nitrates were present, uncomfortably close to the drinking water standard of 10 mg/l.

Because of the nitrate problem, the search for a new city well was expanded to several other sites, and some test holes were drilled. No other location, however, has proved to yield as high a flow rate of water as the first, and the city is uncertain about what to do next.

Shortly after the contamination problem was discovered, the Michigan Department of Natural Resources (DNR) became involved in investigating the source of the organics. A site visit to a small manufacturing firm 500 feet from the well and subsequent soil samples at that site tentatively implicated that firm as the source. The DNR sent in a drilling crew to establish ground water flows and outline the contamination zone. In drilling six monitoring wells, three different ground-water flow directions were noted. Although water levels were the same in all wells, it was very difficult to pump much water out of the rock for analysis. In short, investigative efforts have been stymied by unusual hydrogeologic conditions along the shoreline.

The above ground investigations by DNR on the plant site have been more successful. In the spring of 1982, officials from the DNR field office came on site and had barrels of hazardous wastes removed. An area of contaminated soil was also excavated. The excavation was covered with an impermeable liner and then backfilled. The purpose of the liner is to prevent more substances from leaching into the ground-water table. The owners of the manufacturing plant have been cooperative in assisting cleanup efforts.

CURRENT STATUS

Presently, the City of Petoskey is still trying to find a satisfactory site for a new, secure well. The city and state have spent over $200,000 thus far on the case. The Michigan Department of Public Health is still assisting the City in finding a new source, and has recently met with the City's engineers to authorize more test wells. The Petoskey City Council has been under pressure from the press and the public to show progress in resolving the contamination problem. Finally, DNR has slackened efforts to trace the source of contamination through hydrogeologic studies. Thus far, the state has not been able to make a solid case against the suspected source.

INSTITUTIONAL INVOLVEMENTS

As in most cases, institutional response to the detection of organics in Petoskey's well was focused in two areas. The Michigan Department of Public

Health had been urging Petoskey to find a new well, and accelerated efforts to find a new drinking water source once the old well was found to be contaminated. The Department of Natural Resources directed efforts to find and control the source of contamination, including drilling monitoring wells near the production well and suspected source and conducting a hazardous waste excavation and removal project on the industrial sites.

HEALTH GUIDELINES

The Director of Public Health in Michigan recommends that public exposure to potential carcinogens be limited as much as possible, promoting a no-threshold-level policy. In a situation such as that at Battle Creek, where lost water production from contaminated wells can be mostly made up by increasing pumpage from clear wells, this policy means that any well showing organics contamination should be closed. At Petoskey, however, where the City depends on one well for its entire water supply, the potential hazards of closing that well are greater than the risks associated with keeping the well open. The only option in this case was to notify the public and accelerate the search for alternate supplies.

CONCLUSIONS

The Petoskey case was the only situation studied in which a well defined as contaminated was still being used. Present trichloroethylene levels are around 20 ppb, a concentration that would be quite acceptable in New York, where the state guidelines limit a single VOC to 50 ppb. Local and state officials expressed a need for more health effects information to get a better idea of the health risks faced by Petoskey residents.

Another stumbling block in resolving the Petoskey case was the difficulty with drilling and monitoring along the lakefront. The shallow rock and unusual hydrology have stalled efforts to trace the trichloroethylene and dichloroethylene found in the City's well back to the source. Although responsibility has not been proven, the industry suspected of being the source has cooperated with surface cleanup plans.

NEW BRIGHTON
MINNESOTA

SUMMARY

In July 1981, the City of New Brighton was notified by the Minnesota Department of Health that trichloroethylene and other, related organic solvents had been identified in most of the city's wells. The city discontinued use of the most heavily contaminated wells and increased pumpage from the uncontaminated wells, supplemented as needed by water from mildly contaminated wells. The public was notified of the problem and sprinkling restrictions were announced to keep demand down during peak-use summer months. A request for Superfund assistance in developing new water supplies was turned down, but the city began a program of recompleting wells in deeper intervals anyway, at a fairly large expense. At present, the previously "clean" wells are picking up traces of contamination, but the newly-completed wells appear free of organics and should be able to meet immediate demands. Efforts to trace the source of contamination have centered around the Twin City Army Ammunition Plant, and the Army has begun on-site investigations.

BACKGROUND

The City of New Brighton is a suburb on the north side of Minneapolis, Minnesota. The Department of Public Works has a total of eight fairly deep (around 400 feet) wells serving 23,500 of the city's residents. At the time organic contamination was discovered, average daily demand was about 2.5 MGD with summer peaks running around 6 to 7 MGD. Only six of the eight wells were on line at that time, since one well was down for repairs and the oldest well was used only as a standby supply.

DISCOVERY OF THE CONTAMINATION PROBLEM

By early 1981, the Minnesota Pollution Control Agency (MPCA) had set up a strike force unit to identify and investigate hazardous waste dump sites. Acting on a tip about past disposal practices at the Twin Cities Army Ammunition Plant (referred to as the "arsenal"), MPCA sampled private wells around the arsenal in July. When a variety of organic chemicals in well water were identified in this testing, the Pollution Control Agency immediately notified the Minnesota Department of Health (MDH), the agency with jurisdiction over public water supplies.

The Department of Health sampled public wells in the area and discovered the contamination to be fairly widespread. The water supplies for the City of New Brighton, two other municipalities, the arsenal and a trailer park were found to be contaminated, as were several hundred private wells near the arsenal. Trichloroethylene, trichloroethane, dichloroethylene, and dichloroethane were the contaminants detected most frequently. Of the New Brighton wells, four had TCE concentrations between 150 and 200 ppb, two had concentrations from 5 to 10 ppb, and two wells showed no traces of contamination. One of the originally uncontaminated wells has since shown 20-30 ppb of TCE, leaving the city with only one clean well.

ACTIONS TO PROTECT WATER QUALITY

The Department of Health took a second set of samples to confirm the initial results and notified New Brighton. In discussions with the city, MDH interpreted the health risks of the moderately high levels of organics found in the city wells and outlined possible options to reduce the risk to public health. The Department of Health used both the EPA Suggested No Adverse

Response Levels (SNARLS) and the NAS increased cancer risk estimates in explaining the situation to city officials. Minnesota had not had a similar case of gross contamination by VOCs before, but the state reacted quickly in setting a zero-exposure goal to reduce exposure to potential carcinogens as much as possible.

The short-term control method was to close the most heavily contaminated wells. The City established a pumping scheme to bring contaminated wells on line only when water demands required, in reverse order by the degree of contamination. This temporary solution allowed base (winter) demands to be met, but still meant that contaminated wells would have to be used in the summer. The other immediate action taken was to notify the public of the problem. The City hand-delivered letters to all its customers explaining the problem and possible health effects. Shortly thereafter, the press and television media grabbed the story and put out enough misinformation to make it difficult for the City and MDH to keep the situation under control.

The State outlined three long-term control options that New Brighton could take, basically treatment to remove the organics, new well construction to find an uncontaminated source, or connection to an adjacent municipal water system. Since the adjacent system, the City of Minneapolis, had a history of taste and odor complaints with its surface water system, and since treatment was not thought to be a complete solution, the City opted for a well construction program.

With the assistance of the Pollution Control Agency, New Brighton applied to EPA for Superfund money to recomplete two existing wells into deeper, clean formations, at a cost of $500,000. The November 1981 application for funds to develop an alternative source by deepening existing wells was denied because the site did not meet criteria for an immediate removal. An EPA Technical Assistance Team and a Field Investigation Team have studied the site.

The City proceeded without EPA assistance to have the two most heavily contaminated wells recompleted in a deeper (1000 feet) aquifer in September 1981. The State required strict quality control measures, including special casing, to eliminate the possiblity of contaminants migrating to previously-clean zones along the well bore. Cross-contamination of clean aquifers by aquifers carrying organic chemicals is often a major concern when monitoring or production wells are drilled through more than one aquifer. One of the two recompleted wells came on line in the summer of 1982 and the other was to follow shortly. In the meantime, the City imposed and enforced strict sprinkling bans to keep summer demands low. On five occasions, water emergencies were declared. Samples taken in the distribution system when the city was forced to put a contaminated well on line occasionally reached 10 to 15 ppb of trichloroethylene.

The Minnesota Pollution Control Agency has been the agency most involved in tracing the source of contamination and has been following an investigation program estimated to cost over $500,000. The MPCA sampled local wells and found that high concentrations of organics were present in wells on one side of the arsenal (the side nearest the New Brighton well field) and that no organics were present in wells on the other three sides. With some EPA Superfund money for off-site well drilling, MPCA defined the extent of contamination more closely. These data and information on TCE and solvents use at the arsenal were used to persuade the Army to do an on-site study. Officials at the arsenal originally balked, but became cooperative after political pressure was applied by the local Congressional delegation. Monitoring wells have now been drilled in Phase I of the Installation Restoration Program sponsored by the Department of Defense.

EPA offered the assistance of a Field Investigation Team in January 1982. The FIT examined four other potential sources of contamination between New Brighton and the arsenal, drilled and sampled eighteen monitoring wells, sampled 150 existing wells surrounding the arsenal, and started a surface-water sampling program. The investigation showed that the direction of ground-water flow was from the arsenal toward New Brighton and that the zone of contamination was highest on the downgradient side of the facility. One other site, a solvent recycler, had high levels of organics nearby, and the owner has begun investigations on-site in response to a request by MPCA.

CURRENT STATUS

Efforts are currently proceeding on two fronts in the New Brighton case. The Minnesota Department of Health is still working with the City to develop alternative sources of drinking water. Towards that end, the second of two recompleted wells is expected to come on line soon and a new drilling program is planned. By the summer of 1983, the City hopes to drill three new deep wells, bringing the total of good wells to six, capable of meeting even summer demands. Voters in New Brighton passed a $2.6 million bond issue for further well construction in the November 1982 election. MDH performed the background work and well site surveys required to locate the new wells.

In terms of tracing the source, the Minnesota Pollution Control Agency is continuing to gather evidence on the source of the organics showing up in local wells. The DPH is engaged in discussions with the arsenal to determine culpability and work out some cleanup agreement.

INSTITUTIONAL INVOLVEMENT

The agencies involved in resolving the organics problem are split into two groups. On one side, the City of New Brighton and Minnesota Department of Health have the goal of protecting the public health by providing safe drinking water. Working in complementary fields, the Minnesota Pollution Control Agency and EPA are charged with removing the threat to health by identifying and halting the source of contamination.

The City of New Brighton is handling the problem internally, without hiring a consulting engineering firm. Good communication with the state agencies has allowed the City to make reasonably informed decisions, and the City has made strong efforts to protect the quality of water distributed to its residents. The City and DPH originally shared organics analyses expenses, but New Brighton now contracts with a private lab.

The state agencies are facing budget reductions but still have been responsive to New Brighton's problems. The Department of Health is the lead agency on drinking water quality issues. MDH has a capable but small staff knowledgeable about organics and ground water. With the discovery of several organic problems in state ground water, however, the Department is being severely taxed to respond and cannot handle much more. Laboratory capacity is especially limited. MDH has contacted EPA Region V several times for information but has generally relied on internal resources.

The Minnesota Pollution Control Agency has been the lead agency involved in determining the extent and source of the north Minneapolis area organics problem. Relations between MPCA and MDH are reported to be good. Since the Pollution Control Agency also has a fairly limited budget, agency policy has been generally to identify the party responsible for contamination incidents and turn over further investigations and expenses to the responsible party. MPCA has spent many weeks preparing requests for EPA to provide assistance in emergency and remedial measures.

EPA involvement in the New Brighton case has mainly been through the Region V office, except for headquarters involvement in Superfund decisions. State officials say that the Region V office has been very helpful in responding to the New Brighton area problem. EPA headquarters has been reportedly less helpful in supplying information.

HEALTH GUIDELINES

The Minnesota Department of Health reportedly uses a 1 in 10^5 increased cancer risk level concentration of 27 ppb as the guideline for trichloroethylene. TCE is usually used as the indicator organic. The EPA Cancer Assessment Group (CAG) did estimate that a 1 in 10^5 increased risk would be associated with 20 ppb, but no other health department interviewed used the CAG figures to set guidelines and no other department mentioned a 27 ppb guideline. The source, therefore, of the health guideline numbers reported for Minnesota is uncertain.

CONCLUSIONS

The main points of the New Brighton case of ground-water contamination by organic solvents can be summarized as follows:

- Widespread contamination, potentially a very serious problem.
- Department of Defense involvement slowed response.
- State performed reasonably well but has no established program.
- Lack of health information is a problem.

- Media involvement complicated the situation.
- No EPA funds for immediate removals, although some Superfund money has been made available.

State officials believe that the whole investigation around the Twin City Army Ammunition Plant was hampered by the fact that the arsenal is a federal facility and that EPA was very leery of getting involved in a conflict with the Department of Defense. According to the National Contingency Plan, Defense is responsible for dealing with hazardous waste problems on their own property, but responsibility for off-site migration of contaminants seems to be an unresolved issue. The Army apparently took the position in this case that their responsibility ended at their property boundary. Although another small source may have contributed to the problem of organic chemicals in the local ground water, it does appear that the arsenal was the primary source. This premise has not been proven absolutely, given the difficulties in tracing subsurface flows of chemicals that are becoming fairly ubiquitous.

Another difficulty faced by state officials was in obtaining a commitment from EPA to spend Superfund monies on remedial or emergency actions. The Pollution Control Agency has submitted at least three applications for long-term relief, emergency actions (planned removal request), and initial remedial measures, none of which have been approved. DCA officials have not understood why the decisions have been made against them. Along the same lines, the state has wondered why EPA has been so hesitant in the New Brighton case to fund alternative water supplies.

An issue related to Superfund decisions is the lack of health effects information or standards for organics in drinking water. On one side of this problem, the City was unable to convince the media that the levels of organics present were not extremely hazardous. On the other hand, the state was unable to convince EPA that TCE levels varying from 1 to 150 ppb were serious enough to require emergency action to supply an alternate water supply. The lack of a "hard" number on which to base decisions on protecting public health also makes it difficult to recover damages from polluters.

Overall, some measure of certainty in response would have been helpful in resolving several aspects of the New Brighton case. It was difficult to decide on closing wells without solid health guidelines. Quite a bit of effort was expended to obtain EPA Superfund assistance without knowing whether such assistance would be forthcoming. The responsibility of the Army in cleaning up the organics problem is still under negotiation. The failure of all parties involved to coordinate a broad investigation of the total area of contamination, now estimated to be 18 square miles, was also due to uncertainties about funding and each party's degree of responsibility, although the State was in favor of such a study. The delays caused by these uncertainties have caused the health risk to remain and have allowed the organic plume to migrate further, contaminating another New Brighton well and placing the water supply of the next municipality downgradient in jeopardy.

CITY OF TUCSON
PIMA COUNTY, ARIZONA

SUMMARY

Prompted by a state-wide surface impoundment study, EPA undertook a field investigation of certain uncontrolled hazardous waste sites in Arizona early in 1981. The investigation of the Hughes facility, the number one potential source of contamination, near Tucson Airport revealed the presence of various contaminants in wells at and near the facility. The results of further sampling showed 77 ppb of trichloroethylene in one Tucson Water Department well, leading to the closure of that well. Continued monitoring has revealed organic contaminants in eight other public wells, five of which have been closed. Tucson's water production capacity has not yet been significantly affected.

Soil borings and downgradient monitoring wells have been used to verify suspected disposal areas and determine migration of the contamination plume. Preliminary government efforts were concentrated on plume identification and waste stream/source studies on the assumption that a detailed hydrogeologic study contracted by Hughes would be available, but Hughes refused to release the report until the summer of 1982. Some activity on treatment research and clean-up alternatives has begun since the Air Force announced a $3 million commitment to treat water from the contaminated wells. Previous estimates of total clean-up costs ranged up to $20 million. The ongoing search to positively identify contamination sites has been expanded from just the Hughes facility to the Tucson Airport area as a whole.

BACKGROUND

The City of Tucson Water Department is one of the largest public water suppliers in the state. Tucson Water operates over 240 wells, with the number in service at any one time dependent upon demand. The annual average demand is about 70 mgd, with winter lows of 50 mgd and summer peaks near 150 mgd. The City of Tucson only consumes about 15 percent of the base demand. Seventy percent is used for irrigation and the remainder is consumed in copper mining operations south of the city.

A typical Tucson water well is about 800 feet deep. The upper regional aquifer begins 100 to 150 feet below ground level and is roughly 100 feet thick. A tight clay zone separates the upper aquifer from the lower, another 100 feet [illegible]. Most wells are screened at both intervals, but the majority of water produced is from the upper zone since the lower zone is less permeable. Tucson water well fields are scattered over a large part of the Tucson Basin.

Tucson International Airport is located about five miles south of the center of the city. U.S. Air Force Plant No. 44, operated by Hughes Aircraft, Missile Systems Group, is on the south edge of airport property about one mile east of Nogales Highway. The facility is spread over approximately two square miles. Of nearly a hundred structures, the main building (#801) is the source of most of the liquid effluents and general industrial wastes. Various metal finishing and electroplating operations are performed in this building and others.

Land use near the Hughes facility is principally medium to heavy industrial manufacturing sparsely situated on large parcels of extremely flat, arid land. The area immediately surrounding the airport to the south and west was reportedly used by up to six aircraft manufacturing and retrofitting operations from World War II to the Korean War. Approximately one mile west of Building

801 and one-half mile from currently-used wastewater impoundments, low-income single family residences border Nogales Highway. Trailers and small mobile home parks are common along Nogales Highway, south of the airport. Most of these residences rely on deep 200-600 foot municipal and domestic wells drilled adjacent to the highway.

DISCOVERY OF THE CONTAMINATION PROBLEM

In December 1979, the Arizona Department of Health Services (ADHS) completed a state-wide assessment of surface impoundment sites. Along with evaluating the potential for ground-water pollution by percolation and infiltration from surface waste impoundments in the state, the report ranked the major sites for further investigation. Air Force Plant No. 44, operated by Hughes Aircraft, was highest on the list, having reportedly caused the contamination of nearby wells with chromium, cadmium, and arsenic. Tucson Water Department's Well SC-7, located about one mile west of the Hughes facility, had exceeded the EPA Drinking Water Standard for chromium on at least three occasions since 1975.

On the basis of the ADHS study, EPA Region IX selected the Hughes facility for further investigation under the Uncontrolled Hazardous Waste Site Investigation Program. An extensive amount of background information was gathered before EPA's Field Investigation Team went on site on March 5, 1981 to collect water samples and examine the facility. This information included well logs, previous ground-water quality analyses, aerial photographs, and other official documents relating to the plant's operation. A special effort was made to analyze historical chemical usage and waste disposal practices.

EPA's consultants conducting the on-site investigation (Ecology and Environment, Inc.) found three Hughes wells contaminated with trichloroethylene; one as high as 4,600 ppb. At the same time, Tucson Water Well SC-7, on the far side of Nogales Highway and one mile west of the most heavily contaminated Hughes well, yielded 77 ppb TCE. These samples were taken during the first week of March 1981. The test results came back two months later. Since the state had no action levels for VOCs, they and Tucson officials spent several days looking for references. The same action levels used by the State of California were adopted temporarily and SC-7 was closed on May 12.

A follow-up investigation May 26-28 involved gathering some on-site soil samples and samples from previously inaccessible Hughes wells in addition to ten municipal and private wells north and west of the facility. One additional Tucson well (C-62) was found to be contaminated and subsequently closed on June 29. The presence of TCE and chromium in wells operated by Hughes was confirmed (as high as 13,000 ppb TCE) at that time. As more wells have been sampled in successively wider circles, water from four more Tucson wells has been found to contain significant amounts (over 5 ppb) of TCE and have been closed. The most recent closure of an active well was November 1981, but testing has continued. All of the wells contaminated lie in a swath stretching to the northwest from the Hughes facility, although it is unlikely that Hughes is the only source responsible.

ACTIONS TO PROTECT DRINKING WATER QUALITY

As discussed above, Arizona had no policy for dealing with volatile organics in ground water in 1981. Historically, Tucson has had very good water from deep, ancient aquifers. EPA had even used Tucson water as a baseline for naturally-occurring organics, so officials were caught off-guard when a serious contamination problem was discovered.

The state tentatively established an action level of 5 ppb for trichloroethylene, the same level suggested by the State of California. Five parts per billion is roughly the NAS' 1 in 10^6 increased cancer risk level; the concentration at which one additional case of cancer per million people consuming 2 liters of water per day over a 70 year lifetime may be expected. Six Tucson water wells were taken out of service for exceeding this guideline. ADHS released the final Guidelines for TCE in Public Water Supplies in March 1982, discussed later in this case study.

After the analytical results from water and soil samples taken by E&E during the May follow-up investigation were reviewed, some long-term planning began. In September 1981 interagency meetings were held to define the scope, tasks, and areas of responsibility for investigating and removing the threat to Tucson's water. Ecology and Environment's Interim Composite Report on Intergovernmental Agency Activities, submitted to EPA Region IX, contains a framework of tasks and subtasks, reproduced here as Exhibit 1, and a chronology of major investigative events, reproduced here as Exhibit 2. These exhibits outline each study activity, agency responsible, and planned and actual dates of accomplishment. The government agencies most heavily involved in planning and carrying out the work plan have been:

- U.S. Environmental Protection Agency (EPA)
    - -- Region IX, San Francisco
    - -- Ecology and Environment, Inc.

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Figure 2.1 (Interim Report)
SCOPE OF WORK - TUCSON TCE INVESTIGATION

ACTIVITY	RESPONSIBLE AGENCY	-1981-			-1982-									
		OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT
I.HYDROGEOLOGICAL STUDY														
A.Well inventory	*DWR	X	X											
B.Determination of Static Water Levels	*Tucson Water/DWR			X	X									
C.Definition of Sub Surface Geology	*DWR/Tucson Water		X	X										
1.Interpretation of Data	*Ken Schmidt				X									
D.Determination of Aquifer Characteristics	*DWR/Tucson Water		X	X	X									
E.Development of Water Budget for Industries	*E&E/Industries	X	X	X	X	X								
F.Evaluation of Current Chemical Quality	*BWQC/Tucson Water	X	X	X	X									
G.Evaluation of Historical Chemical Quality	*Tucson Water/BWQC	X	X	X	X									
H.Conduct Borehole Geophysical Study	*EPA Contractor			X	X									
1.Interpretation of Data	*Ken Schmidt					X								
I.Preparation of Report - Draft	*Ken Schmidt						X							
Final								X						
II.WASTE STREAM/SOURCE STUDY														
A.Analysis of Aerial Photography	*BWC/E&E	X	X											
B.Evaluation of Historical Landuse & Industrial Practice	*BWC	X	X	X										
C.Characterization of Solid Waste	*EPA Contractor/E&E/BWC		X	X	X									
D.Development of Waste Budget for Industries	*E&E/BWC/Industries			X	X	X								
E.Preparation of Report - Draft	*E&E						X							
Final	*E&E							X						
III.PLUME IDENTIFICATION														
A.Determination of Geographic Extent	*BWQC/Tucson Water/E&E		X	X	X									
B.Determination of Vertical Extent	*EPA/Tucson Water/E&E	X	X	X	X	X								
1.Existing wells														
2.New wells							X	X	X	X	X	X	X	
C.Vadose Zone Sampling	*EPA Contractor							X	X	X	X	X	X	
D.Development of Monitoring Wells	*EPA Contractor							X	X	X	X	X	X	
E.Identification of Origin of Plume(Source)	*EPA/Ken Schmidt	X	X	X	X	X	X	X	X	X	X	X	X	
F.Preparation of Report - Draft	*E&E/Ken Schmidt												X	
Final	*E&E													X

* Indicates lead agency

SUPPLEMENTAL ACTIVITIES	RESPONSIBLE AGENCY	
IV.Treatment/Cleanup Alternatives		
A.Literature (case study) Search	*BWQC/E&E	
B.Evaluation of		
1.Extraction/Solids removal option	*BWC/E&E	
2.Treatment/disposal options	*BWC/BWQC/E&E	
C.Development of Water System Management Program	*Tucson Water	
D.Selection and Implementation of alternatives	*EPA/BWC/BWQC/E&E	
V.HEALTH IMPACTS		
A.Epidemiological Survey	*DDC	
1.Who is impacted?		
2.How are they impacted?		
B.Evaluation of Health Costs	*DDC	
VI.OTHER		
A.Development of Laboratory Network	*EPA	

BWC - Bureau of Waste Control
BWQC- Bureau of Water Quality Control
DDC - Division of Disease Control
DWR - Department of Water Resources
E&E - Ecology & Environment
EPA - Environmental Protection Agency

TABLE 2.1 CHRONOLOGY OF MAJOR INVESTIGATIVE EVENTS

DATE	ACTIVITY DESCRIPTION	AGENCY PARTICIPATION
3/3 - 5/81	Site inspection of Hughes Aircraft/USAF Plant # 44; 11 water samples collected from onsite and offsite municipal, industrial, and private wells	EPA/E&E; TW
4/15/81	Draft preliminary site inspection report submitted to Hughes Aircraft Co..for comment	EPA
5/26 - 28/81	Followup investigation of Tucson Airport area; 14 water samples collected from onsite and offsite wells; onsite wells resampled plus Credit Union well and Hughes Well #2; 3 soil samples collected from former waste water impoundments; ADHS collects duplicates of offsite wells	EPA/E&E; TW; ADHS
6/18/81	HAC critique of draft preliminary report received and draft report revised; report released 6/29/81	EPA/E&E
7/17-11/2/81	A total of 93 water samples from 52 municipal and private wells. Sample collection dates 7/17, 7/20, 8/3, 8/11, 8/12, 8/24, 9/2, 9/16, 9/30, 11/2.	ADHS BWC; ADHS BWQ
7/17/81-4/8/82	Distribution system sampling (ave. 7 samples/set)	TW; ADHS BWQ
9/8-10/81	Shallow soil borings; 22 samples collected in areas selected by ADHS in over 8 sections ranging from drainage ditches south of Irvington Road to various areas on HAC property. Report TSC14-2(81)177 issued by EPA on 1/8/82	ADHS/BWC; EPA; EPA/E&E
9/22-23/81	Inter-agency coordination meetings; develop conceptual tasks and assign responsibilities; establish reporting framework	EPA: EPA/E&E; ADHS; AzAG; TW; AzDWR
11/81	Well Inventory; historical water quality data search; water level measurements	DWR; TW
1/12-31/82	6 soil borings to 150' in five separate locations (TAA fire fighting training area, HAC FACO dump, HAC abandoned metal precipitate pits, HAC abandonned wastewater impoundment, TAA landfill); 115 samples collected	ADHS BWC
1/25-2/8/82	Tucson Airport Authority well #10 aquifer test; abandoned well reactivated, pumped for 2 weeks, and periodically sampled. Duplicate samples collected for ADHS BWQ and EPA/E&E by TW; 15 sets of samples collected.	TW; EPA/E&E

DATE	ACTIVITY DESCRIPTION	AGENCY PARTICIPATION
3/2-5/82	Tucson Airport Authority wells #1 and #5 aquifer tests; abandoned wells reactivated, pumped 1-2 days each; 7 samples collected at TAA #1; 9 samples collected at TAA #5 plus blank from distribution system.	TW; EPA/E&E; EPA
3/15-18/82	Attempted monitoring well installation; revised scope of work resulted in collection of 3 water samples and 8 soil samples collected from 3 locations (TAA landfill, drainage ditch at entrance to Tucson Aviation Center off Nogales Highway, drainage ditch immediately south of Warner Prop. Co. Tucson Aviation Ctr.)	ADHS/BWC; EPA; EPA/E&E
3/15/82	RCRA 3007 information requests sent to Airport Area industries for waste practice investigation; responses received circa 4/10/82	EPA
4/13-6/1/82	Aquifer testing; B-102, SC-7, B-85, B-101, B-87, C-64, C-62, B-103	TW
5/10-14/82	Intermediate depth soil borings; 59 samples collected in 23 soiling borings at a depth of approximately 15 feet; 6 general areas selected on basis of historical alleged sources of disposal.	EPA/E&E
6/1/82	Hughes Aircraft/Hargis & Montgomery hydrogeological study made available to EPA	EPA
8/82	5 monitoring wells scheduled for installation; Coordination with San Xavier Indain Reservation, Gates Learjet, and Hughes Aircraft. Phase II monitoring wells pending results.	EPA; EPA/E&E

EPA - U. S. Environmental Protection Agency, Region IX, San Francisco, CA
EPA/E&E - Ecology & Environment, Inc. Field Investigation Team
ADHS/BWC - Arizona Department of Health Services/Bureau of Waste Control
ADHS/BWQ - Arizona Department of Health Services/Bureau of Water Quality
TW - Tucson Water Department
DWR - Arizona Department of Water Resources
AzAG - Arizona Attorney General

- Arizona Department of Health Services (ADHS)
    - -- Bureau of Water Quality
    - -- Bureau of Waste Control
- City of Tucson Water Department
- Arizona Department of Water Resources

CURRENT STATUS

Since June 1982, developments have occurred on several fronts. Hughes finally released the hydrogeologic report prepared by their consultants, after EPA negotiated and filed suit for the information. EPA directed the construction of five monitoring wells on Indian land west of Nogales Highway. The county health department became active in the case. The major development was announced by the Air Force in October. In a lengthy press release, the Air Force stated its intention to spend $3 million under its Installation Restoration Program (IRP) to clean up the Tucson aquifer. Previous estimates of the cost of clean-up had ranged up to $20 million.

After major negotiations, the Air Force committed itself to a plan to pump contaminated ground water to a treatment plant capable of removing the subject organics. One and a half million dollars has been allocated for redesigning and replacing pumps and pipes and making other alterations at Hughes' treatment plant to allow pumping at 450 gpm. Another $1.2 million has been allocated for drilling 15 reclamation wells "spread strategically within the zone of contamination." The cost of booster pumps and 35,000 feet of pipelines are included in that figure. The final $300,000 has been approved for designing a treatment system. These remedial actions are to be implemented when EPA's efforts to define the extent of the contamination plume are complete. EPA has already spent over $500,000 on the case.

In the same press release, the Air Force verified that contamination migrating off-site had forced Tucson to close Well SC-7. The Air Force was not involved in early discussions on the contamination problem but has now stated that "the contaminants ... were used by Hughes in its operations at the plant (and) percolated through the soil from waste treatment ponds."

INSTITUTIONAL INVOLVEMENT

The responsibilities and participation of the major government agencies involved in the Tucson ground water problem have been as follows:

- **U.S. Environmental Protection Agency (EPA).** EPA has been directly involved in every step of detecting and resolving the problem. The state-wide surface impoundment assessment by ADHS that uncovered the problem was largely funded by EPA, as is ADHS itself. EPA's uncontrolled hazardous waste site program was responsible for confirming the presence of TCE and other contaminants. Region IX personnel and their main contractor, Ecology and Environment, Inc., have been heavily involved in hydrogeological studies, waste stream/source analysis, plume identification and treatment/clean-up research.

- **Arizona Department of Health Services (ADHS).** Despite budget cutbacks and organizational changes, ADHS has played a major role in the Tucson case. ADHS is the regulatory agency with primary responsibility for ground-water protection, safe drinking water and control of hazardous wastes in Arizona. Therefore, when the contamination problem was discovered, EPA reportedly asked ADHS to take the lead in the case, also for the purpose of avoiding intergovernmental conflicts. Since then, ADHS has coordinated all local, state, and federal TCE-related activities.

  This responsibility has been a major drain on health department resources. Since the state had no contingency plan for dealing with a ground-water contamination incident as serious as that discovered in Tucson, funding and manpower had to be borrowed from existing programs, causing other services to be cut back. Reorganizations have shifted responsibility back and forth between safe drinking water, hazardous waste, and ground-water protection (a group that was scheduled to be phased out in 1981) programs. A special group was recently set up to manage the continuing investigations and implementation of remedial actions in the TCE problem areas as well as to oversee the utilization of monies obtained under the CERCLA and Arizona's Water Quality Assurance Revolving Fund (WQARF).

The Water Quality Assurance Revolving Fund is Arizona's version of Superfund, set up by the state legislature in response to the discovery of trichloroethylene and other contaminants in Tucson area wells. The monies in the WQARF can be used to assist in the clean-up or removal of contaminants from ground water or as state matching funds against federal remedial actions related to groundwater problems. The WQARF was funded to $500,000 in 1982, with half of that, the maximum allowable for one site, already committed to the Tucson case.

- **City of Tucson Water Department.** Tucson Water, the agency most directly affected by the discovery of organics in the Tucson aquifer, had not only the funding but the technical expertise to respond to the problem. Since the water department still had ample capacity after the well closings, it was in no hurry to resolve the contamination problem if in doing so, water department funds would be expended. On the contrary, Tucson Water chose to limit their involvement and see if a federal or state source could be found to fund investigative and remedial actions. Tucson Water expenditures on the case were generally related to pump tests and sample collection. Although the State had to struggle to come up with $50,000 for emergency drilling, Tucson Water reportedly had several times that amount available in one of several program budgets.

  These facts are not intended in any way to put the blame on Tucson Water for not responding as quickly as possible, but to point out a dilemma that is not unique to this case. As long as the water system could still meet demand and as long as no immediate threat to other wells was obvious, there was no incentive for the department to rush in and spend their own money when other funding sources could be exploited. Some clarification of EPA policy on reimbursement for funds already expended might have speeded the department's response.

- **Pima County Health Department.** In the summer of 1982, the county health department became involved in the organics issue since it was brought up as a highly publicized, politicized health hazard. Pima County began an extensive search for private wells near the airport that had not yet been tested and handled sample collection for the state.

  The county went one step further due to the interest aroused by publicity on the case. At a public hearing in September 1982, monitoring requirements for all public and semi-public water systems in the county were proposed. In the form of a County Ordinance, this proposal would require annual testing by each system for volatile organics. In addition to the cost burden on small system operators (some of which supply only 5 to 10 customers), enforcement of the ordinance would be difficult.

- Arizona Department of Water Resouces (ADWR). The Department of Water Resources is another agency involved in the coordination and planning of meetings. As the state agency responsible for keeping track of the quantity of water resources, ADWR assisted the overall effort by conducting a well inventory and providing historical water quality data and water level measurements. Drilling logs and well specifications have also been helpful in developing an idea of the previously-unstudied hydrogeology of many problem areas.

HEALTH GUIDELINES

As previously discussed, the health hazards posed by organic chemicals found in Tucson's water forced ADHS to adopt temporary guidelines for TCE which were finalized in March 1982. ADHS is currently re-evaluating the guidelines issued in March to address the issue of TCE risk relative to other hazards, such as the trihalomethanes prevalent in surface-water supplies near Phoenix.

CONCLUSIONS

As might be expected of a "potentially disastrous" contamination problem involving a large number of actors, the response to trichloroethylene and other organics detected in wells near Hughes has not proceeded perfectly. Some difficulties raised by officials involved in the investigation are noted below:

- Hughes' refusal to release the hydrogeological information collected by their consultant, Hargis and Montgomery, slowed investigative efforts, reduced the possibility of a coordinated response, and caused undue friction.

- The uncertainties and time involved in getting the Tucson Airport Area on EPA's Interim Priority Superfund (CERCLA) List delayed investigative efforts and caused several steps of the workplan to be eliminated due to funding constraints.
- Tucson Water Department had the necessary resources but expended no great effort in response because it hoped to obtain EPA funds.
- ADHS was caught unprepared and had to fight budget cutbacks, public pressure, and a lack of technical expertise to respond.

These problems served to slow but not stop progress on the case. In the end, the Air Force came through with funding from a Department of Defense IRP grant. This and Superfund monies have caused Hughes and the government health agencies to increase their respective levels of effort towards resolving the problem.

Several other difficulties unrelated to the amount of money spent in Tucson remain. Health effects information on the contaminants detected is incomplete and not easily understood by the public. In a state such as Arizona, the health department does not have the resources required to conduct health research and must depend on the federal government. Similarly, many states do not have the expertise required to set guidelines or regulations for carcinogens and again must rely on more capable agencies, although even EPA has yet to decide on regulations for some synthetic organic compounds.

Another weakness is in knowledge of the transport and decomposition of organics in the soil and ground-water environments. Local officials did not have much faith in the ability of existing models to predict plume movement. Some type of chemical finger-printing was also mentioned as a technology that would help to positively identify sources of contamination.

GREAT OAKS WATER COMPANY, SAN JOSE, CALIFORNIA

SUMMARY

The Great Oaks Water Company (GOWC) in San Jose was notified by Fairchild in December 1981 that trichloroethane had been found in wells on Fairchild's plant site. A nearby GOWC well was then tested for volatile organics. When the test results showed the well water was contaminated by 5,700 ppb of trichloroethane, the well was taken out of service. Fairchild, GOWC, and the half-dozen agencies with jurisdiction over health and water issues then began meeting to determine the extent of contamination and resolve the problem.

Soil borings and monitoring wells have outlined the area of contamination around a leaking waste solvent tank on Fairchild property, and the firm has been pumping the contaminated GOWC well through carbon-packed bottles to waste to keep the trichloroethane from migrating to other wells. The water company had enough capacity to meet demands during the relatively cool summer of 1982 but is concerned about other down-gradient wells becoming contaminated. Great Oaks is also concerned about its reputation and solvency in the face of several lawsuits alleging damages to public health.

BACKGROUND

The Great Oaks Water Company is an investor-owned utility regulated by the California Public Utilities Commission. The company was founded in 1959 to provide water to an unserviced area in South San Jose, and has grown rapidly with the development of the local electronics industry; now serving an estimated 70,000 persons through 16,000 connections. GOWC prides itself on providing excellent service to the community at very reasonable rates, arrived at through careful planning and budgeting.

Before the contamination problem was discovered, GOWC was operating 13 wells. An average daily demand would be about 10-12 mgd, with summer peaks as high as 19 mgd. The water company has a 1.5 million gallon.elevated storage tank for peak leveling and fire protection, but the widely dispersed wells pump directly into the distribution system so localized pressure drops can occur when a well is taken out of service.

DISCOVERY OF CONTAMINATION

In November of 1981, a Fairchild crew noticed discolored soil and smelled solvent fumes while excavating near the south-west corner of the South San Jose plant for a new underground storage tank. Fairchild did some soil borings and tested an on-site well shortly thereafter to determine the source of the apparent leak. Great Oaks Water Company officials noticed the drilling activity, since the plant site was directly across the street from their offices, but knew nothing of the problem until Fairchild informed them on December 4 that trichloroethane had been found in a Fairchild well one hundred feet from the plant. Since the notification was given late on a Friday afternoon, the President of GOWC wasn't able to contact state officials for advice on how to proceed until the following Monday. On that day, Fairchild's consultants (EMCON) tested GOWC Well No. 13 and the domestic water supply in the Fairchild plant. The plant's water showed only 0.7 ppb of trichloroethane, but Well No. 13 showed 5,700 ppb of trichloroethane.

At this point it is interesting to note that in 1980 the State Department of Health Services had conducted a study of volatile halocarbon contamination in four ground-water basins. Trichloroethylene and tetrachloroethylene were chosen as indicators of contamination because of their widespread use and dispersion, ease and sensitivity of analysis, environmental persistence (resistence to degradation) and high mobility. Of 183 wells sampled in the Santa Clara Valley, only three wells showed any traces of TCE or PCE contamination and none of these tested over 1.0 ppb. Great Oaks Water Company Well No. 13 was sampled and scheduled for TCE/PCE and purgeable organics analysis, but the sample was apparently lost, as no results were ever reported. Results for Well No. 13 could have either alerted officials to the contamination problem considerably earlier or established a base date at which the contaminant plume had not reached the well.

ACTIONS TO PROTECT WATER QUALITY

Closing the contaminated well was the first short-term step in protecting the quality of water delivered to Great Oaks' customers. Since the concentration of trichloroethane in Well No. 13 was almost twenty times as high as California's 'Action Level' (discussed later), the need for this action was not questioned. Organizing working groups to trace the source and to plan remedial actions was another effort undertaken shortly after the contamination was discovered.

Beginning in December 1981, the water and health agencies with either responsibility for or an interest in the problem began meeting at least every other week. The purpose of the meetings was to plan monitoring and long-term clean-up actions, as well as to report individual progress. At first, some officials were confident that the entire problem would be resolved within three months, but more cautious voices have proved correct as no comprehensive plan for remedial action has emerged as of eleven months after the leak was discovered. The organizations usually represented at the meetings have been the Great Oaks Water Company, Fairchild, the Santa Clara County Health Department, the Santa Clara Valley Water District, the Regional Water Quality Control Board, the State Department of Health Services, and various consultants.

When the contamination problem was discovered, Fairchild's consultant was EMCON. EMCON drilled about eight monitoring wells on-site in an initial attempt to define the area of contamination. After it became apparent that the scope of the problem was expanding, Woodward-Clyde Consultants were commissioned by Fairchild to define the plume and suggest clean-up measures. Also in early 1982, Fairchild paid to have one GOWC well (No. 4) deepened to increase production capacity, at a cost of about $30,000.

Woodward-Clyde took soil borings or drilled monitoring wells at 23 locations on Fairchild property and constructed another 19 monitoring wells downgradient from the property. Eight private wells in the area were also sampled. In January Woodward-Clyde had decided that Well No. 13 had to be pumped to waste to halt the spread of the plume to other wells, and later set up a row of monitoring wells as an early-warning system for other GOWC production wells. Their report "Hydrogeologic Studies at Fairchild Camera and Instrument Corporation, MOS Facility" was finished in May 1982 and reportedly cost Fairchild about $500,000. The Woodward-Clyde report seemed to explain the hydrogeologic characteristics of the region and define the areal extent of the TCA plume fairly well, but no suggestions were made for cleaning-up the source. The report apparently did include a contingency plan for responding if the trichloroethane moved past the contaminated GOWC well.

Fairchild designed and had installed an unusual system for removing the trichloroethane from Well No. 13 water before pumping it to waste. The contaminated well is now pumped through isolated GOWC lines to a filtration system on the Fairchild site. About 1,700 gpm of contaminated water is pumped through 750 to 800 individual carbon bottles connected in parallel, each tank treating slightly more than 2 gpm. The Regional Water Quality Control Board has approved a maximum effluent concentration of 30 ppb for water dumped to a storm drain on-site. Fairchild also had several large carbon contactor tanks installed in June and July of 1982 to remove organics from water pumped from a purge well near the leak site. Because of very high influent concentrations (over 10,000 ppb), the tanks are currently treating only a tenth of their total design capacity of 2,000 gpm. Fairchild is reportedly spending $5,000 to $6,000 per day on carbon replacement alone.

At present, after extensive evaluation, Fairchild has selected another consulting firm, Canonie Environmental, to continue working on the aquifer contamination problem. Fairchild has been thinking recently about removing the organics from contaminated water by an air-stripper process, but nobody seems to know what levels of trichloroethane are safe in air. The Air Resources Control Board would have responsibility for the necessary emissions standards, but the characteristics of the substance and the legal definition of "source" are still uncertain. The questions associated with transferring a potential carcinogen from one medium to another have yet to be resolved.

CURRENT STATUS

At present, the extent of trichloroethane in South San Jose ground water has been fairly well defined. Great Oaks water supplies are sufficient for the short-term, and it appears that Fairchild will be involved in cleaning up the contamination. GOWC has probably the most-often tested water in the country, with Fairchild and IBM running organic analyses weekly. IBM has been spending about $6 to 8 thousand per month on testing and GOWC has been spending an equal amount. Fairchild's expenses have been even higher. The overall situation seems fairly well in hand, but some problems remain.

Some local residents are dissatisfied with official responses to the problem. Articles in the local press (viewed as "sensationalist reporting" by local officials) have aroused public interest in the trichloroethane problem to a "hysterical" pitch. One point of contention is that Fairchild did not notify the public of the trichloroethane leak until after a newspaper printed the story a month after Well No. 13 was closed. Local and state officials maintain that notification was postponed while the extent of the health hazard was being studied, and that the contaminated well had been closed down immediately regardless of notification. One lawsuit has been filed over this alleged negligence.

Another point of contention is the failure of state and local government to set standards for organic chemicals and to follow through on enforcement of these standards. A class action suit has been filed by 150 people against the Regional Water Quality Control Board, the State Department of Health Services, the City of San Jose, the Santa Clara Valley Water District and others alleging negligence in protecting public health.

Most recently, in May 1982, a multi-million dollar lawsuit was filed by eight South San Jose couples claiming they have been harmed by the contamination. Led by a mother of a child with a congenital birth defect, the group brought suit against Fairchild and GOWC. Prompted by public outcry, the State Department of Health Services announced in late September a study to investigate possible links between the contaminated well and birth defects in one neighborhood. The study, which could cost up to $100,000, should be concluded by September 1983.

INSTITUTIONAL INVOLVEMENT

Several of the mild organizational conflicts and the perceived lack of progress encountered in responding to the organics problem in Great Oaks Water Company wells were due to the myriad of overlapping jurisdictions in the State of California. The following summary attempts to explain the mandate and involvement of each organization:

- **Regional Water Quality Control Board (RWQCB).** The RWQCB was officially the lead agency in the Great Oaks case. As the agency with overall responsibility for water quality in the state, the RWQCB was looked to for direction. Unfortunately, for some reason, the Board was slow to react to the problem in South San Jose, and several of the other agencies became frustrated at constant delays. Relations were smoothed out somewhat in the work groups.

- **State Department of Health Services (DHS).** California DHS is charged with protecting the health of the public and therefore has jurisdiction over public water supply wells. Two DHS groups, the Sanitary Engineering Branch and the Hazardous Waste Management Division have been involved in the Great Oaks case. The primary role of DHS has been in administering drinking water standards and monitoring requirements. DHS has also provided information on the health effects of various organics found in water systems. Of the state agencies, DHS is probably best equipped to serve as a clearinghouse for health information. The Department doesn't have a toxicologist or a huge staff, but they do try to keep abreast of developments in health research and occasionally go to EPA for assistance in answering complicated requests.

- **Santa Clara Valley Water District (SCVWD).** The SCVWD is in charge of water conservation and flood control in the Valley. The Water District operates surface reservoirs and artificial recharge basins as the local agency for surface and ground-water supplies. Although the SCVWD does have ordinance and revenue powers, it usually relies on the less-cumbersome authority of the RWQCB when enforcement actions are necessary. In the GOWC case, the Water District sits in on meetings and reviews proposals for exploration and remedial measures. As the custodian of all well logs in the Valley and the body most familiar with ground-water flows, the SCVWD must approve any well drilling activity. In this capacity, the Water District rejected a plan to pump out, clean-up, and reinject contaminated water on the grounds that until the contamination area was defined, changes in flow patterns might disperse the plume.

- **Santa Clara County Health Department (SCCHD).** In California, the County Health Departments are responsible for enforcing SDWA monitoring requirements and water quality standards for small, semi-private and private water systems. When Fairchild announced it had discovered the trichloroethane problem, it was the Santa Clara County Health Department that checked the nearby small community systems for organic contamination. Over a hundred samples were taken, but no nearby wells were found to be contaminated. The County is quite concerned about the threats posed to over 5,000 private wells. The SCCHD role in the Great Oaks case has been to supplement the State Health Department by taking responsibility for the small community systems, as well as to participate in the planning meetings with the rest of the agencies.

- **Great Oaks Water Company (GOWC).** As discussed earlier, the GOWC is a medium-sized investor-owned utility. As such, the Water Company is subject to Public Utilities Commission rules and must meet all the same Health Department water quality standards as the public (municipal) water systems. A major difference is that a private utility isn't eligible for public grant money for defining and cleaning up a contamination problem.

- **U.S. Environmental Protection Agency (EPA).** The Region IX EPA office in San Francisco and the headquarters Office of Drinking Water, Criteria and Standards Division have been involved in the Great Oaks case. Region IX has had little to do with the case except to answer occasional questions from DHS. Region IX has not assisted the local agencies. The director of the Criteria and Standards Division of the Office of Drinking Water at headquarters and his staff have reportedly been helpful in supplying health information.

- **Consulting Firms.** At least four consulting firms have been working on various aspects of ground-water contamination in the Great Oaks Water Company service area. Fairchild has had EMCON, Woodward-Clyde Consultants, and Canonie Environmental working on- and off-site. IBM has hired Brown & Caldwell as part of their rapid response to a potential contamination problem near their facility.

HEALTH GUIDELINES

The California Department of Health Services has recommended a set of "Action Levels" for organic chemical compounds found in domestic water supplies. These guidelines are essentially the EPA SNARLs. The Action Levels are generally set at the carcinogenic risk levels where a 1 in 1,000,000 excess lifetime cancer risk is estimated, although some variances up to the 1 in 100,000 risk level are allowed if alternate water supplies are not available. DHS plans to expand the list of Action Levels as more information becomes available from EPA or as major incidents of contamination force the issue.

CONCLUSIONS

In addition to complaints from consumers and lawsuits over past practices, the problem presently affecting local officials is that nothing has been done to clean up the source or the aquifer and no actions have been approved for the near future. This concerns water and health officials who are worried about continuing contamination and the potential of the contamination plume spreading to other wells. They believe that the difficulties caused by the involvement of so many agencies, the defensive attitude of the industrial source, and the failure of the lead agency to act decisively have slowed responses to the problem to the point that no resolution is in sight, a far cry from early predictions that the problem could be cleared up in three months.

According to most officials interviewed, the major weaknesses in dealing with the trichloroethane problem were related to health information and guidelines. The need for EPA to continue research on the health effects of organics and to then promulgate standards (rather than loose guidelines) based on that health information and an assessment of risks was voiced frequently. Other topics suggested for research were the detention and transport of organic chemicals in the subsurface and ground-water environments. Less expensive testing and monitoring techniques were also called for, but the major area where EPA assistance was thought necessary was in performing health research, distributing health effects information in a form understandable by the public, and establishing enforceable standards.

LAKEWOOD WATER DISTRICT
PIERCE COUNTY, WASHINGTON

SUMMARY

The Tacoma-Pierce County Health Department (TPCHD) and the State Department of Social and Health Services (DSHS) conducted a survey of surface and groundwater quality in late 1980. Traces of organic chemicals appeared in a sample taken from a Lakewood Water District well. Followup sampling by DSHS and EPA Region X confirmed that relatively high levels of 1,2 trans-dichloroethylene, trichloroethylene, and tetrachloroethylene were present in two adjacent Lakewood wells.

EPA took the lead in a two-phase approach to the problem. The first phase consisted of an immediate health response (closing the contaminated wells) and planning meetings with the agencies involved to coordinate efforts in determining the extent of contamination. In the second phase, the EPA, state and local health departments, state Department of Ecology, Lakewood Water District, and the Air Force met to identify the source and discuss corrective actions.

The Water District lost about one-tenth of its production capacity when the two wells were closed in August 1981. In addition to problems with low water pressure in that corner of the District, summer demands were difficult to meet, so sprinkling restrictions had to be implemented. A new, deeper well was drilled to augment water supplies, but that effort only produced a dry hole. The Water District and other local agencies have admitted that nothing could have been done without EPA's technical and financial assistance, but are disappointed at the slow pace of progress in the case.

BACKGROUND

Pierce County is located at the southeastern end of Puget Sound in western Washington State. It is roughly 1,790 square miles in area and extends from Puget Sound to the crest of the Cascade Mountains Range, a distance of about 75 miles. Most of the County's 501,000 people live in central Pierce County, primarily in the cities of Tacoma and Puyallup and the unincorporated areas surrounding Tacoma, including Lakewood.

The highest density residential and commercial growth has occurred in central Pierce County, primarily in the area south of the City of Puyallup and in the communities of Lakewood, Parkland and Spanaway, all south of Tacoma. Developmental pressures in the Lakewood area have been heightened by the expanded use of nearby McChord Air Force Base and Fort Lewis since World War II. Nearly all growth in unincorporated Pierce County has occurred without the benefit of public sewer systems. Community storm water drainage systems are also virtually absent outside of cities, making storm water injection through drain wells commonplace in many areas. Only one major protected surface-water source exists in the county, that serving the majority of needs for the City of Tacoma. Drinking water for most areas of developing Pierce County has been supplied by many small public and private water systems tapping underlying ground-water aquifers.

The geology of the Pierce County area is an important factor in ground-water studies. The region is crossed by several well-defined channels cut by glacial meltwater streams which left substantial deposits of coarse sands and gravel known as the Steilacoom gravels. Several of these channels are the ancestral tributaries of the Lakewood area drainage basin known as Clover and Chambers Creek. Due to the high velocity and erosional effects of these meltwater streams, and to glacial anomalies in the local geology, the normally protective glacial till layers are absent in some areas, permitting rapid recharge through the overlying highly permeable Steilacoom gravels. The unconsolidated glacial drift and alluvium underlying the area contain aquifers of very high porosity and permeability that yield high flow rates of water. The highly permeable gravels and steep gradient make rapid transport of groundwater contaminants a serious problem.

The Lakewood Water District draws all of its water from these highly permeable aquifers, using 25 wells screened at intervals varying from 110 to 800 feet deep. The Water District serves over 40,000 persons in a twenty square mile area southwest of Tacoma. Wide variations in demand are due primarily to lawn sprinkling in this mostly-residential area: average demands are near 6 mgd, with summer averages of 15 to 18 mgd and the peak 1982 demand at 22 mgd.

Most of the Lakewood wells are pumped directly into the distribution system, although the Water District does have a small amount of storage capacity. Some of the wells receive chlorination, and all are sampled weekly for bacteria, a concern in this unsewered area.

DISCOVERY OF THE CONTAMINATION PROBLEM

In response to growing concerns about the effects of rapid development on ground-water quality, DSHS directed a study in 1980 to investigate the extent of aquifer contamination in the Clover Creek-Chambers Creek Basin. The study was designed to document ground-water quality, identify any trends in groundwater quality related to development, and recommend areas for further study. The analysis of existing data showed that a significant problem did exist and recommended a comprehensive survey of water quality be made as soon as possible.

The comprehensive survey began in November 1980 and was concluded in February 1981. The Department of Social and Health Services performed the survey, with the aid of the Tacoma-Pierce County Health Department. EPA agreed to assist by running organics analyses on 24 samples collected throughout the basin. Lakewood Water District Well No. H-1 was selected for analysis partly to satisfy geographical diversity and partly for its proximity to McChord Air Force Base.

The results of the February tests came back later in the spring, showing that 1,2 trans-dichloroethylene, trichloroethylene, and tetrachloroethylene were present in Well No. H-1. Follow-up sampling by EPA and DSHS in July and August confirmed that H-1 and H-2, a nearby well in the same production zone, were both contaminated. The the results of those tests were as follows:

HIGHER LEVELS OF CONTAMINANTS DETECTED (ppb)

	Well #1	Well #2
1,2 trans-dichloroethylene	37	138
trichloroethylene	7	18
tetrachloroethylene	29	138

ACTIONS TO PROTECT WATER QUALITY

Since the levels of contamination in both wells exceeded the NAS contaminant level for a 1 in 100,000 increased cancer risk by as much as 600 percent, immediate action was necessary. The following account of responses to the discovery of VOC contamination is taken partly from a paper presented at the AWWA 1982 Annual Meeting by William A. Mullen (Region X Drinking Water Program Chief) and others.

The Water District, State Departments of Health and Ecology, Tacoma-Pierce County Health Department, EPA, and the U.S. Air Force formed a work group to develop and implement an action plan. The action plan was broken down into three phases: removing the health threat, determining the source of contamination, and taking remedial measures to restore or replace Lakewood's water supply.

In the first phase, concurrent with the planning process, several actions were taken immediately. The Water District voluntarily removed the wells from service in mid-August and notified its customers regarding the problem. A sampling program was begun to assure that contaminated water had been flushed from the system, and nearby homeowners with private wells were urged to contact the Tacoma-Pierce County Health Department so that sampling could be arranged. Those wells, along with other public water supply wells in the area, were sampled by EPA to ensure that any public health threat had been eliminated. Wells on McChord Air Force Base were sampled jointly by EPA and the Air Force.

In the second phase of the EPA investigation, beginning in November 1981, a number of monitoring wells were drilled to determine the source of contamination. Ten shallow (28 to 35 feet) interactive wells were drilled by EPA from November to February around the contaminated Lakewood wells. These wells, drilled at a total cost of about $10,000, showed some contamination in the upper aquifer, but at concentrations an order of magnitude lower than those in H-1 and H-2. Pump testing of the two Lakewood wells, however, showed there was some interconnection, possibly through a poorly-cased well bore, between the two aquifers.

In January 1982 the hypothesis that the upper aquifer was the carrier of contamination was abandoned, and efforts were concentrated on the lower aquifer. By this time the Water District was becoming frustrated with the apparent lack of progress and therefore contracted for a deep multilevel well near H-2 with their own money, rather than waiting for authorization through EPA and EPA's contractor, Ecology and Environment (E&E), Inc. EPA provided technical assistance on this well and did the testing, which showed the highest contamination at a depth of 90 feet.

The information gathered from the multilevel well was used to design a deeper drilling program. Beginning in June 1982, a series of deep holes have been drilled around H-1 and H-2 in an effort to trace the flow of contaminants in the deeper aquifer (below 90 feet). A cable tool rig has been used for these test holes because it is much more controllable and provides better samples than an air rotary rig. The seventh deep well has just been completed, and EPA officials expect the next well to confirm their suspicions that the contaminant plume is flowing from a source in the direction of nearby McChord Air Force Base. To date, only about $36,000 has been spent on the 10 shallow wells, one multilevel well, and seven deep monitoring wells.

As the above activities were proceeding, the Air Force carried out some investigations on-base. The Air Force and EPA checked the eight wells on McChord Air Force Base after organics were discovered in H-1 and H-2, but found only trace levels. In addition, quarterly surface-water sampling has not shown organics concentrations higher than allowed by the Base's NPDES discharge permit. Most other investigations on the Base have been related to the Air Force's Installation Restoration Program.

The Installation Restoration Program (IRP) is essentially the Air Force's version of Superfund. IRP is a four-phase program targeted at identification of potential waste storage areas through to the final restoration of any dump sites which may require clean-up. Phase I, a detailed analysis of records, including a history of operations, the geological and hydrological conditions which may contribute to migration of pollutants off installations, and a search of ecological files for evidence of any environmental effects resulting from contamination, was completed by CH2M and Hill in July 1982 and made public. Phase II, a field survey of the installation, consisting of soil and water sampling to confirm the presence of specific migrating pollutants, was begun shortly thereafter by JRB Associates. The first two phases are estimated to cost the Air Force $370,000. Phase III and IV, containment and remedial actions, will depend on the findings of Phase II. Based on preliminary findings, the Headquarters Air Force Engineering and Services Center program directors have moved McChord from below number fifty to about number twelve on "the list" of installation priority sites. Some of these actions were accelerated when a local congressman, in his efforts to find a culprit in the Lakewood incident, initiated a congressional investigation into the case last spring.

CURRENT STATUS

The second of three phases to resolve the Lakewood problem is currently in progress. The immediate health hazard has been removed, and EPA is optimistic that drilling efforts in October and November will all but pin down the source of contamination. Phase three, remedial action to ensure that Lakewood Water

District has a safe long-term supply, will likely take quite a while, based on the quantity of VOCs already pulled out of the production wells and the fact that increasing concentrations have been reported in some wells.

INSTITUTIONAL INVOLVEMENT

At least a half dozen organizations have been directly involved in resolving the problem of organic compounds in Lakewood Water District's ground-water supply. The 'round-table' approach to planning and decision-making has attempted to take advantage of expertise held by each group. The following briefly describes the role of each organization in the Lakewood case.

- **U.S. Environmental Protection Agency (EPA).** The Drinking Water Programs Branch of EPA's Region X in Seattle has been the lead agency in coordinating a response to the Lakewood contamination problem. Other agencies have stated that they simply could not have handled the problem without technical and financial assistance from EPA. In terms of technical assistance, EPA or EPA's contractor ran the organics analyses that originally discovered the problem, performed further sampling in confirmation, drilled the shallow monitoring wells, supervised the multi-level well, and is now drilling a series of deep wells that are expected to pinpoint the source of contamination. Since the state and county have no capacity for laboratory analyses of organics, EPA has generally been responsible for all testing.

  For technical information, EPA officials in Seattle have contacted EPA headquarters, various consulting firms with experience in hydrogeology, and personal sources at other Regional Offices. For health information, the Seattle office has usually turned to the Office of Drinking Water at headquarters in Washington, D.C. Professional journals and water industry conferences have also been credited as valuable sources of information for those organizations with enough personnel and resources to keep up with current events.

- **State Department of Social and Health Services (DSHS).** The Department of Social and Health Services is responsible for the quality of water distributed to the public. In this capacity, it deals with water utilities on sampling and compliance requirements and provides information on treatment. Although DSHS is the primary health agency in the State of Washington, it has not established a program to deal with contamination of ground-water sources and has no plans to establish any guidelines for organics in drinking water. In the absence of any state program for responding to VOC contamination, DSHS has handled each incident individually, referring to the EPA Office of Drinking Water's "Guidelines in Response to Contamination Detected in Groundwater Supply Survey" and to other agencies for suggestions on how to proceed.

The Department of Social and Health Services is handicapped in dealing with problems such as organics in the Lakewood wells for several reasons. First of all, there seems to be some confusion at the state level as to who exactly is responsible for this new type of problem. Some coordination in the roles of DSHS and the Department of Ecology would be helpful. Secondly, the state has been hardhit by budget cuts and has not looked favorably on expanding health service related activities. Finally, DSHS has a shortage of personnel qualified to deal with organics or ground water. The civil engineers traditionally concerned with conventional water or wastewater treatment just have not been trained in hydrogeology or toxicology, and the state has no lab space for organics analysis.

- **Department of Ecology (DoE).** The State of Washington Department of Ecology is more concerned with the resource aspects of ground-water contamination than the health effects. In the Lakewood case, DoE was involved in the debate over local growth and land use planning that prompted the DSHS study (with the cooperation of DoE and Tacoma-Pierce County Health Department) of ground-water quality. Because of jurisdictional conflicts, including one over the Commencement Bay Superfund site, and the commitment of a large share of resources elsewhere, DoE has not played a major role in the Lakewood contamination problem. The Department of Ecology has, however, assisted in the initial ground-water basin study and in surface surveys of potential sources of organic contaminants.

- **Tacoma-Pierce County Health Department (TPCHD).** Under an agreement with DSHS, the local health department has responsibility over some small water and sewer systems. Without the financial or technical resources to do any complicated testing, however, the Tacoma-Pierce County Health Department has been unable to take much responsibility over ground-water issues.

  The Health Department has been heavily involved in several aspects of the Lakewood case. The TPCHD helped the State select well sites for sampling in the initial ground-water basin study. Health Department officials urged DSHS to recommend closing the Lakewood Water District's contaminated wells early, after the first round of testing. More recently, the department has been conducting historical surveys into the use and disposal of organic compounds in the Tacoma-Pierce County area. This information is being used to gain insight as to potential contamination sites as well as to aid in the development of a comprehensive land use policy.

Since the Tacoma-Pierce County Health Department could not afford to do any drilling or even organics scans, they credit EPA for making any progress in the case possible. At the same time, TPCHD was mildly critical of the slowness of response and several lapses in communications between themselves and the federal organizations.

- **United States Air Force (USAF).** The Air Force and Army have maintained large installations south of Tacoma since before World War II. McChord Air Force Base property, beginning several hundred yards from the contaminated Lakewood wells, consists of over 1,000 acres on which live about 6,500 people associated with the Base's flying mission.

  McChord Air Force Base was the immediate suspect when the trichloroethylene, tetrachloroethylene, and dichloroethylene (compounds often associated with aircraft-type degreasers) were discovered at H-1 and H-2. As of September 1982, no evidence has conclusively implicated or exonerated the Air Force as the source of the volatile organics. Under the USAF Installation Restoration Project (described previously), Base personnel and their consultants carried out an extensive study of organics use and disposal practices.

- **Lakewood Water District.** The Lakewood Water District's main concern in the organics contamination case has been with finding a suitable location for a new production well. After extensive studies, one deep well was drilled a mile downgradient of the contaminated wells. Continuous monitoring showed no detectable organics as drilling passed through the aquifer level contaminated at Well No.s H-1 and H-2. Lakewood has not taken a significant role in tracing the source of contamination.

HEALTH GUIDELINES

As mentioned earlier, the State of Washington has not set guidelines for volatile organics in drinking water. The EPA SNARLs are therefore the only real guidance the health agencies have in responding to cases of contamination. The obvious difficulty with this approach is that the SNARLs document can be interpreted in many ways. Lakewood Wells H-1 and H-2 contained over 200 ppb of each of the organics detected, well over the maximum recommended concentrations other states suggest (usually on the order of 5 to 50 ppb). For this reason the health agencies were unanimous in recommending that the wells be taken out of service.

If circumstances had differed, the response might have been less predictable. An EPA official in Seattle thought a standard should be set at a risk level between $1/10^6$ and $1/10^7$ excess cases of cancer, roughly equivalent to a TCE level between 4.5 and 0.45 ppb. An Air Force official said he would be concerned if over 10 ppb of TCE showed up in his wells, a risk level between $1/10^5$ and $1/10^6$. Most state guidelines recommend using water with no more than 5 to 50 ppb of TCE, depending on the availability of alternate supplies. The Lakewood Water District Superintendent did not seem to think that a 1 in 4,000 risk level of excess lifetime cancer risks was excessive. All parties involved called for someone, usually an agency with higher authority, to set some defensible guidelines.

CONCLUSIONS

The response to the discovery of trichloroethylene, tetrachloroethylene, and dichloroethylene in Lakewood Water District wells was slowed by a lack of financial resources, little previous experience with VOCs in ground water, and the regional attitude that resource contamination is an East Coast problem, not a Washington problem. Overall, the organizations involved were fairly well organized and responded to the best of their abilities. Several weaknesses, however, were highlighted by officials working on the case:

- Health effects information still contains lots of unknowns and needs to be improved;

- Some type of public education effort would be helpful to explain the magnitude of risks in understandable terms;
- Streamlined funding and response mechanisms would eliminate frustration over delays perceived by the public as unresponsiveness to the problem;
- A clearinghouse for information on treatment options and other technical aspects should be set up and publicized;
- A lack of qualified hydrologist/geologist professionals requires present staff to be spread thin at times;
- Some type of inhouse or external peer review process for study plans would help if the response was rapid;
- Some standard well placement and monitoring procedures would be a good fallback;
- Communication between the levels of government involved in organics contamination cases needs to be improved;
- The federal government needs to recognize that in most cases, local governments cannot shoulder this type of burden.

To reiterate, better health information and clear guidelines are the two most critical areas where research efforts should be concentrated. Other areas where assistance would be helpful are drilling and monitoring, and hydrogeological investigations, in general.

APPENDIX D

LIST OF CONTACTS

GROUND-WATER CASE STUDIES

PHONE INTERVIEWS

Bedford, Massachusetts

EPA Region I - Eliot Thomas	(617) 223-6688
Town of Bedford - Steve Daly, Town Administrator	(617) 275-1111
Massachusetts Water Pollution Control Office	
Massachusetts Department of Environmental Quality Engineering - Jerry McCall	(617) 292-5500
Camp, Dresser, McKee - Donna D'Amore	(617) 742-5151

Garden City Park, New York

Water District Superintendent - John Mirando	(516) 746-3194
Assistant Superintendent - John Guarino	(516) 746-3194
Nassau County Health Department - Frank Padar	(516) 535-3324
N.C.H.D. Bureau of Water Supply - Michael Alarcon, Director	(516) 535-3323
New York Bureau of Public Water Supply Protection - John Orndorff, Director	(518) 474-5577

Vestal, New York

Town Engineer - Tom Goettle	(607) 748-1514
Consultant - Ray or John Martin	(607) 724-3226
New York Department of Environmental Conservation - Mike Marchie	
New York Department of Health - Jim McCarthy	
New York Bureau of Public Water Supply Protection - John Orndorff, Director	(518) 474-5577

PHONE INTERVIEWS (Continued)

North Pennsylvania Water Authority, Pennsylvania

North Pennsylvania Water Authority - Harry Borchers, Executive Manager	(215) 855-3617
North Pennsylvania Water Authority - Judy Wright	(215) 885-3617
EPA Region III - Bob Ranowski, Karen Dewald	(215) 597-9873

Vero Beach, Florida

Lab Supervisor - John TenEyck	(305) 562-5124
EPA Region IV - Mark McClanahan, Toxicologist	(404) 881-3781
Florida Department of Environmental Regulation - Glen Dykes (also William Bostwick, Fred Huttner, Mickey Bryant)	(904) 488-3601
Harper-Branch Research Foundation - Dr. Tsen Wang	(305) 567-7196

New Brighton, Minnesota

City Engineer - Les Proper	(612) 633-1533
Minnesota Department of Health - Gary Englund, Chief, Water Supply Section	(612) 296-5330
Minnesota Department of Health - Dick Clark, Supervisor, Engineering Unit	(612) 623-5227
Minnesota Pollution Control Agency - Steve Lee	(612) 297-2720

Petoskey, Michigan

City Manager - Steven Hoffner	(616) 347-4105
Public Works Superintendent - Frank McCune	(616) 347-4105
MDPH - District Engineer - Tim Benton	(517) 373-1376
MDPH - Public Water Supply Division Jim Cleland	(517) 373-1376
Michigan Department of Natural Resources - Dan Cummins, Geologist	(517) 373-2508
Petoskey Water Superintendent - Pete Adams	(616) 347-5550
District Health Office - Dr. Brian Young	(616) 347-6014

PHONE INTERVIEWS (Continued)

South Brunswick, New Jersey

Public Works - Larry Merk	(201) 329-4000
Township Health Officer - Robert Harris	(201) 329-4000
IBM - Chaim Luria	(201) 329-7704
New Jersey DEP Geologist - Bill Altoff	(609) 292-0668
New Jersey Bureau of Potable Water - Barker Hamill	(609) 292-5550
Geraghty-Miller - Erhardt Werth	(516) 921-6060

[illegible]ITE VISITS

Glen Cove, New York

Director, Public Works - Joe Hurley	(516) 676-2000
Superintendent - Anthony Caruso	(516) 676-2000
Nassau County Department of Health - Don Myott, Frank Padar	(516) 535-3323
Nassau County Bureau of Water Supply - Mike Alarcon	(516) 535-3324
New York Bureau of Public Water Supply Protection - John Orndorff, Director	(518) 474-5577
Nebolsine, Kohlmann, Ruggiero Engineers - Dominic Ruggiero	(212) 695-6800

Rockaway Township, New Jersey

Health Department - Richard Christie	(201) 627-7200
Township Engineer - Ron McKinnon	(201) 627-7200
Water Superintendent - Donald Tyrone	(201) 627-7200
Township Attorney - Rich Sirota	(201) 539-1313
New Jersey DEP - Joe McKulka	(609) 292-0577
New Jersey Bureau of Potable Water -Barker Hamill	(609) 292-5550

SITE VISITS (Continued)

Elkhart, Indiana

Water Works Manager - Mike Terlep	(219) 295-2400
State Board of Health - Arnold Viere - Jim Traylor	(317) 633-0210
City Engineer - Bruce Carter	(219) 295-2400
EPA Region V - Michael Strimbu	(313) 886-6202
Canonie Environmental - Roberto 'Rob' Weiss Malik	(219) 926-8651

Battle Creek, Michigan

Michigan DPH - Water Supply Division - Jim Cleland	(517) 373-1376
Michigan DPH - District Engineer - Rick Wirsing	(517) 373-1376
Michigan DNR - Bill Iverson, Section Chief	(517) 373-8147
EPA Region V - Steve Ostrodka	(321) 886-7571
City Utilities Engineer - Larry Osborn	(616) 966-3421
Calhoun County Health Department - Ted Havens	(616) 966-1241

Lakewood, Washington

EPA Region X - Bill Mullen, Section Chief	(206) 442-4092
EPA Region X - Fred Wolfe, Hydrologist	(206) 442-0691
Washington Department of Social and Health Services - Bob James	(206) 464-7671
Tacoma-Pierce County Health Department - Derek Sandison	
Lakewood Water District, Superintendent - Wayne Dunbar	(206) 588-4423
Washington Department of Ecology - Jim Oberlander, Will Abercrombie	
United States Air Force - Captain Lindsay Waterhouse	

SITE VISITS (Continued)

San Jose, California

Great Oaks Water Co. - Ken Krajeyski	(408) 227-9540
Regional Water Quality Control Board - Peter Johnson	(415) 464-4270
Santa Clara County Health Department - Steve Brooks	(408) 279-6060
Santa Clara Valley Water District - Tom Iwamura	(408) 265-2600
Fairchild - Larry Amen	(415) 962-5011
California Health Department (DHS), Engineer - Cliff Bowen	(415) 540-2153
EPA Region IX - Nate Lau, California	(415) 974-

Tucson, Arizona

Water Department - Tom Jefferson	(602) 791-4761
Water Department - Bruce Johnson, Chief Hydrologist	(602) 791-4761
City of Tucson - T.J. Harrison, Attorney	(602) 791-4221
EPA Region IX - George Wilson, Arizona	(415) 974-8274
EPA Region IX - Harry Seraydarian, Toxics Division	(415) 974-7460
Arizona Department of Health Services - Pamela Beilke, DEH	(602) 255-1134
Arizona Department of Water Resources - Ed Nemecek	
Consultant - Ecology & Environment - Dave Buecker	(415) 777-2811
United States Air Force - Charles Alfred, Environmental Program Manager	Wright-Patterson Air Force Base
Hughes Aircraft - Donald Ellerman, Legal Counsel - Edward K. Spaulding, Manager, Environmental Health and Safety	(602) 746-6000